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THE ARCHITECT'S IDEAS ON ILLUMINATING PROBLEMS.

At the recent meeting of the Illuminating Engineering Society a paper was read by Mr. Bassett Jones, Jr., which, under the caption of "The Relation of Architectural Principles to Illuminating Engineering Practice," discussed various problems of illumination from the standpoint of the architect. The paper was not only of unusual interest on account of the author's decided views and his earnest method of presenting them, but because it dwelt on a phase of the whole question which until recently has been but little discussed. The illuminating specialist, in his enthusiasm to reform illuminating practice, which to his trained eye is in such a woful condition, has been energetically criticizing things as he finds them. He has been telling us what practices are wrong, and why; how matters should be set right; and he has not hesitated to lay the blame for what he holds to be bad practice where he thinks it belongs. In fact, whenever he has seen a head, he has hit it, and heads have been plentiful.

Naturally the architect, being the one responsible for the building as a whole, has received his full share of punishment, but until recently little or no attempt has been made to defend him from the charge that he gives too little attention to the artificial lighting of his buildings. On two previous occasions Mr. Jones has had something to say on this matter, and in the last paper, the one referred to above, he goes to some length to explain how the architect views the question of lighting. What the architect wants is an illumination in harmony with the surroundings; in other words, he cares more about the quality of the illumination than the quantity, and his charge against the illuminating engineer is that the latter puts quantity before quality. Mr. Jones tells us what he means by a suitable illumination, and why this is so necessary. In fact, he carries the matter back to fundamental principles, for, he says, upon their development in æsthetic feeling depends the welfare of a people.

Mr. Jones certainly defends the architect's views ably, and all will agree with a part at least of what he says; but when he wishes us to forego many of the advantages incidental to the new forms of illuminants which we have developed, he must bring forward stronger proof. We are willing to have the architect tell us what he believes is suitable illumination, but we can not accept the dictum that only those methods and devices modeled after the practice of the ancients are good. Architecture, perhaps, has made no advance during the past centuries, but engineering has. The architect of the old days used those methods of illumination which were available, but even these

were improvements over still older methods, when the only light available came from the fire on the hearth or altar; and if he had had what we moderns consider better methods, we believe he would have used them to good effect. We to-day are fortunate in having made great strides in our methods of producing artificial light, and it is certainly not to be expected that we should forego all the advantages which these new methods bring except in so far as they can be applied to reproduce or modify the crude methods of long ago. To demand this is, in a way, as unreasonable as it is to ask the builder to use only the old methods of construction.

There is no excuse to-day for any unnecessary waste. When a certain lighting effect is wanted this should be obtained in the most efficient way possible. It is absurd to place lamps within a room to light it and attach them to fixtures which cut off a large part of the light and throw much of the rest where it is not wanted, a practice which reminds one of the White Knight's "plan to dye one's whiskers green and always use so large a fan that they could not be seen." The old fixtures were intended for flaming illuminants, and necessarily these had to be supported from below, and to insist that the designer of electrical fixtures must follow these old patterns is asking him to throw away the advantages going with his systems and to adopt a type of fixture which is very often not at all suitable.

Mr. Jones' paper on the whole will serve a very useful purpose, as it not only indicates that some of the blows aimed at the architects have gone home, but also shows what his ideas are and where pressure should be brought upon him to convince him that there are other and better methods than those which he suggests.

ENGINEERING EDUCATION.

In his annual report to the board of directors of Cornell University, President Jacob Gould Schurman explains the work of the university during the past year and takes occasion to express some interesting views on the subject of technical education. During the past ten years there have been important changes in the curriculum as usually laid out for engineering students. These changes have been necessary in order better to adapt the courses to the rapidly developing professions and arts, and also because of a somewhat different position in the world which the engineer seems to be taking. The engineer of to-day is coming to be more a director of men and of forces than an actual worker, and his education must, therefore, be somewhat broader than can be gained by a mere drilling in science and its application. Engineering problems to-day involve much more than the mere laying of a road or the building of a dynamo. It is necessary not only to make the machines work together properly, but the whole system must be made to fit in with the conditions of the place where it is to be installed. The increasing importance of such systems in our every-day life has increased the importance of the position occupied by the engineer himself, and to fit him properly to meet the changed conditions it is desirable that his training should be somewhat broader than that given in the old technical courses. It is the realization of this which has been bringing about the changes in the college which have been referred to.

In regard to these changes President Schurman says that the courses at present offered, while excellent in the education which they furnish, suffer from a lack of liberal culture and from the disadvantage of being limited too closely to the field of mathematics and physical science. He does not mean that all the work is restricted to these fields, because at almost every college some non-technical work is required, or allowed; but he thinks that there is not enough time given to it; that the modern engineer, if he is to be truly educated, needs a training broader than physical science and technical studies can give him; that he needs the culture of the humanities, and that liberalizing and expansion of mind comes from the study of literature, history and philosophy. But the question is, How is he to obtain this?

President Schurman suggests a remedy which has been offered previously; that is, the lengthening of the course, making it, say, six years instead of four, and requiring about two years of additional general non-technical work. He realizes that a course of this kind can not be put into general operation at the present time, as the conditions are not ripe for it, so he suggests, as a compromise, that the course be made five years, with one year of general work, and at the same time the student be allowed to take, as an alternative, the six-year course, which may be done at present at a number of institutions, and in this way obtain his second degree. He says that he thinks the time has come when this fifth year might be insisted upon at some of the colleges; that this would make it possible for engineers to secure some culture from the humanities, and that it would awaken interest and stimulate tastes which would lead the students to follow these studies after graduation.

It is not likely that any course can be laid down now to remain unaltered for any considerable length of time. The engineering courses must necessarily go through those stages of evolution corresponding to the changes in methods to improvements and to the introduction of new processes which are continuously taking place, and it seems almost inevitable that some lengthening out of the course will eventually become necessary. But it is also true that not all young men who take electrical courses become practicing engineers. For many of them a four-year course is ample, and only the select few need take the additional work.

It should be remembered that the degree given on the completion of the four years of work, at the greater number of our technical colleges, is not an engineering degree; it is only a bachelor's degree. The engineering degree is reserved for those who do an additional two years' work. It is now recognized that a bachelor in engineering is not an engineer, and can not pretend to be such until he has had a good deal of additional experience. With this in mind it would be highly proper, in many cases at least, to cut down some of the technical work which is now offered and substitute for it studies tending to give the student a broader view. If the technical course lays

through a foundation in fundamentals and in theory, the application may be left, to a large extent, to be learned later. In laying these foundations the student will necessarily pick up a great deal of practical information on present-day methods. Bearing in mind that it is the methods which change from year to year, and not the principles, but little is lost if the time devoted to such studies of methods is cut down.

But while such an arrangement is desirable, the proper reason for it should be understood. There is no reason why a scientific study should not be as educational as a study of history, and there is no reason why a man who has devoted most of his time to scientific work should be considered less cultured than one who has spent his days in reading history. In fact, from the scientist's point of view, the other man is just as uncultured as he himself is, although it must be admitted that the general opinion is otherwise. But, why should it be that a classic student may display the deepest ignorance regarding scientific matters, while the finger of scorn is leveled at a physicist should he so much as misplace an accent on a word? Hence, we do not like the argument that the technical student should take outside work for cultural purposes. Rather, it should be said he should do this in order to learn what the rest of the world is thinking about, so that he may not only be more useful to his fellowmen, because he can then get in touch with them more easily, but also for his own sake, in order to take him out of the narrow path in which his daily work is apt to lead him; to interest him in other things in order that he may come back to his own special task with renewed vigor.

DIAGRAMS OF ILLUMINATION.

A very interesting paper was presented at a recent meeting of the Association of Edison Illuminating Companies by Dr. Clayton H. Sharp and Mr. P. S. Millar, which deals with the various distributions given by a number of lighting arrangements. This paper, which was entitled "Experimental Data on Illuminating Values," is published in condensed form on another page of this issue.

One of the interesting features of the paper is the method adopted for presenting the results of each test. A diagram showing the uniformity of illumination is constructed by connecting all points having a given intensity by means of a line, and these lines of equal illumination—"equilucial lines" the authors call them—show at a glance the character of the result. These lines represent on the diagram what the contour lines do upon a map, showing at once where the illumination varies rapidly and where it is more uniform. A number of such diagrams, presented side by side, tell more at a glance about the distribution obtained by systems which they represent than a tedious study of a tabular report. The diagrams, of course, show only the distribution of the light, but complete data for the tests are given in the article.

A PROMISED COMMERCIAL APPLICATION OF ELECTRIC TRANSMISSION OF PICTURES.

Of the various systems of transmitting pictures from photographs over a telegraph wire, that developed by Korn, to which frequent reference has been made, seems to have been brought to the highest stage. By indefatigable work this inventor has overcome a great many of the obstacles which rendered earlier attempts less successful, and he has now, if reports be true, brought it to a point where he can reproduce quickly, clear and satisfactory prints at the receiving end of his line of a photograph or drawing at the transmitting end.

In this system, as in practically all of the others which have been brought to any practical working plane, use is made of a selenium cell which is sensitive to light—that is to say, the resistance of selenium, when in a particular condition, changes with the amount of light falling upon it. If, then, a small beam of light be thrown through a photographic negative and allowed to fall on the selenium cell and then the negative be moved so that the beam travels slowly so as to pass over the entire surface of the negative, a current may be caused to vary by the change in the resistance of the selenium cell, and these variations may be used at the receiving end to produce a reproduction of the original. The method employed by Korn is to cause the variation in current to affect a small shutter at the receiving end so as to cut off, more or less, a beam of light falling upon a sensitive film. This film is made to move in synchronism with the negative at the transmitting end, and thus the reproduction is secured.

The difficulties others have met with have been to overcome the hysteresis, or time-lag, of the transmitting selenium cell, and those which are always met when attempting to maintain two mechanisms in synchronism over a single wire, which is also transmitting the message or picture. The former difficulty has been overcome by placing a second selenium cell at the receiving end, and by a sort of Wheatstone bridge arrangement, the hysteresis of the second is made to compensate for that of the first cell. The problem of synchronism has been simply solved by driving the receiving mechanism a little faster than the transmitting, and then holding it back for a brief instant during each revolution until the transmitting device catches up.

The latest reproductions of the work of this system show a great improvement upon the early ones, which seems to indicate that the method has now reached a fairly practical stage. At least, this is indicated by the statement that a Paris newspaper, *L'Illustration,* is going to try the system, and is arranging for this at Paris and at a number of other European cities. *L'Illustration* is a weekly paper which depends a good deal upon photographs for illustration, and if, by means of the new system, it can save several days in transmission, a week may be gained in the publishing of a picture. The results will be watched with interest everywhere, for the success of this trial may lead to a wider application. There are various uses for which such a quick transmission of pictures would be of the greatest value.

LORD KELVIN DEAD.

THE FAMOUS PHYSICIST PASSED AWAY ON TUESDAY, DECEMBER 17.

Although forewarned by reports of his serious illness, the entire scientific world was shocked to learn on Wednesday morning that Lord Kelvin had died at 10.15 on the night of December 17 at Glasgow. He had been suffering for two weeks from serious complications. For twenty years past he had been suffering from facial neuralgia and had borne it with patience so that few realized that he was suffering.

Personally Lord Kelvin was one of the most charming of men; his modesty and the way in which he inspired affection in all who met him, and the interest and sympathy which he showed toward every one, endeared him to all.

Probably no one has contributed more to the development of physical science than Lord Kelvin; not only was he the leader of his own time, but he was certainly one of the most remarkable men of all ages.

His work in science, while devoted mainly to physics, was often turned to other fields, and he did not disdain to use his great knowledge for putting scientific discoveries to actual use. In fact part of his work of the most immediate importance was that which he gave to developing useful electrical methods and apparatus. He is known as the father of electrical engineering, and surely no one has done more to put this profession on a scientific basis, and in this way raise to a high standard the entire engineering profession.

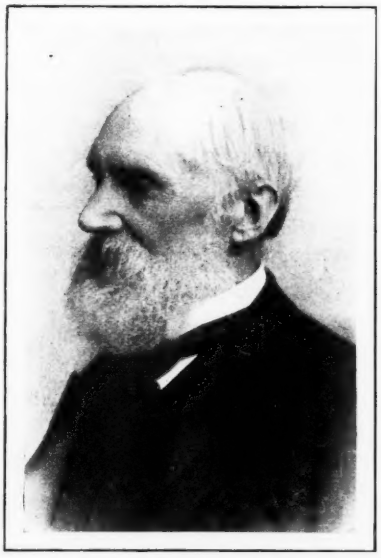
Lord Kelvin was the son of William Thomson and was born on June 25, 1824, at Belfast, Ireland, where his father at that time was professor of mathematics. In 1830 the Thomsons removed to Glasgow, as his father had been appointed professor of mathematics at the university there. William was then eight years old, and at the age of ten he was sent to school, and a year later he entered the university at Glasgow, where he soon distinguished himself by taking first prizes in mathematics.

From this time until 1899, when he gave up his professorship, with the exception of six years spent as a student at St. Peter's College, Cambridge, and a short time in Paris, he was connected with the University at Glasgow, either as a student or a member of the faculty. In order that his almost lifelong connection might not be severed he registered as a matriculate after his resignation.

The abilities of this great man are hard to chronicle. His earliest work which brought him a reputation was in mathematics. In fact his defense of Fourier's theorem in harmonic analysis, written in 1840, when at the age of sixteen, was the first paper he published.

In 1846 he was appointed professor of natural philosophy at Glasgow. At that time he was only twenty-two years old, but even then he was recommended for the position as "the first man of science in the rising generation in England." During the following years he gave much attention to geological theories, using with wonderful effect his great mathematical skill.

It was in telegraphy that he showed his remarkable combination of mathematical



LORD KELVIN.

ability and mechanical ingenuity which distinguished his work. Land telegraphy had been fairly well established and a number of shorter cables laid successfully, but these gave some trouble, and the theory of their behavior was not clearly understood. Thomson took up the subject and worked out a mathematical theory, showing how the behavior of the cable depended upon its dimensions and how it might be improved. It was at this time that he used the hydraulic analogy to make clear to those readers who could not follow the mechanical argument. This notable accomplishment led to his appointment as electrician for the Atlantic Telegraph Company, and he assisted in laying the first Atlantic cable in 1857, after two unsuccessful attempts. In this work Thomson was the main reliance, not only for his grasp of the physical theory, but for the mechanical skill displayed in overcoming the difficulties of the work.

He invented his galvanometer to aid in the work and showed the necessity for using pure copper, requiring the company to specify for the first time copper of "high conductivity" for the cable. The failure of this cable, due to mechanical imperfections merely, encouraged him to continued study, which led to the successful laying of the second cable in 1866, whereby permanent communication was established.

In recognition of his great service in this work he was knighted, and under the name of Sir William Thomson he was long affectionately known.

His taste of sea life while laying the cable brought to his attention the imperfections of the mariner's compass in those days, which resulted in the invention of the greatly improved instrument which today is the standard of the world.

His theoretical knowledge enabled him to predict certain phenomena; one of these, known as the "Thomson effect," is at the present time of particular interest due to recent discoveries in physical science.

He was one of the strongest advocates of the adoption of an absolute system of physical units, and was chairman of the first committee on electrical standards appointed by the British Association.

During the seventies and early eighties he gave considerable thought to electrical applications, designed a number of dynamos and showed, in 1879, that economical high-tension electrical transmission was possible.

In 1892 he was raised to the peerage and upon him was conferred the title of Lord Kelvin.

He delivered an important series of lectures at the Johns Hopkins University in Baltimore in 1890; he was chairman of the International Niagara Commission which awarded prizes for the plans for generation and transmission of power from Niagara Falls.

He visited this country in 1897 and again in 1902. In 1896 there was a great celebration at Glasgow in honor of his fifty-seventh year as professor at that university.

Even within the last few years he had shown no lessening of mental activity and had taken an important part in the discussion of the most recent physical problems.

His death leaves a vacancy which no one to-day can fill.

President Robert C. Clowry Commended.

At a meeting of the directors of the Western Union Telegraph Company, held in New York city on December 11, the following resolution was adopted:

"*Resolved*, That the appreciation of the directors is due to Col. R. C. Clowry and the executive officers of the company for the tact, discretion and prudence with which they have treated the situation arising from the strike of operators."

The Electric Lighting of the Stuyvesant Theatre, New York City.

David Belasco's New Theatre, in West Forty-fourth Street, Equipped with an Elaborate System of Switchboards, Dimmers and Lighting and Auxiliary Services.

WHAT is probably the most modern theatre in the country has been built by David Belasco on West Forty-fourth street, between Broadway and Sixth avenue, New York city. The Stuyvesant Theatre, in addition to its other magnificent appointments, has been equipped with a very elaborate and at the same time very practical system of electric lighting, under the direction of the architect, George Keister, and Mr. Belasco's chief electrician, Louis Hartmann.

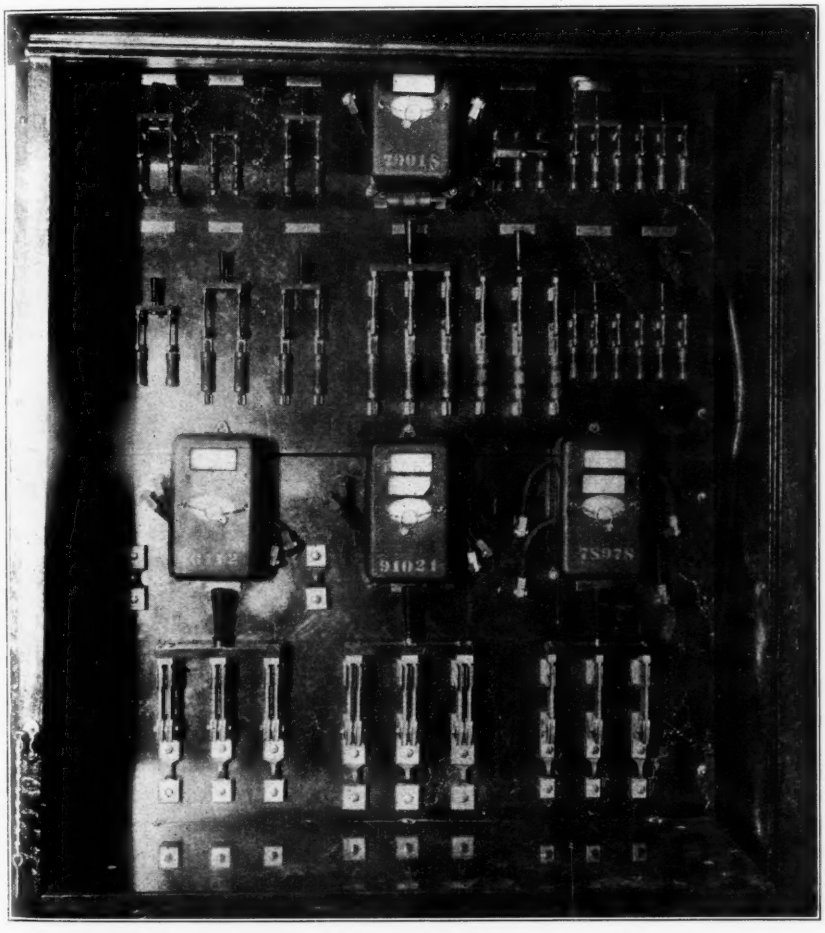


FIG. 1.—MAIN SERVICE SWITCHBOARD.

The theatre uses Edison service, and the company's connections come through two sets of underground mains to the main service board located in the electrician's room in the cellar of the theatre building. An illustration of this board is shown in Fig. 1, and a good idea of the care with which the installation has been made can be had from an inspection of this view.

On the switchboard are mounted sixteen two and three-pole knife switches with enclosed fuses and five meters. From this switchboard two sets of mains are carried to the theatre stage board, one for the incandescent lamps on the stage and in the auditorium, and the other for all arc lighting.

On the main service board are mounted the necessary service meters; three two-wire meters for incandescent lighting and power, and one three-wire meter for front-of-house lighting. There are also mounted on this board ten double-pole switches, which operate two-wire, 220-volt motors for driving ventilating fans, house-pump, fire-pump and induced circulation apparatus.

The theatre is equipped with a triplex cylinder, direct-connected, twenty-five-horse-power pump, connected and controlled by a Cutler-Hammer solenoid outfit with hand-starter, speed-regulating devices and pressure regulators.

From the main service board there are two sets of feeders, one of 1,500,000 circular mils for all incandescent lighting, and an arc feeder of 800,000 circular mils for all arc pockets for the stage. There are provided directly underneath the switchboard two 1,000-ampere, three-pole, single-throw switches for the control of the Edison service.

The stage and auditorium lighting, in the main, is controlled from a splendid Monson slate switchboard twelve feet long and six feet high. This board is built up of polished panels, erected on heavy angle-iron thoroughly reinforced and well braced. The slate for this board has been selected with exceptional care, due to the large number of small holes which had to be drilled in the board. The main stage board is shown in Fig. 2, and a diagrammatic representation of this board appears in Fig. 3. The board contains sixty-nine switches and fifty-nine dimmers. The dimmers are of the standard Ward Leonard pattern, and in addition to these there are two Ward Leonard grid-type house dimmers. The dimmers are all mounted above the main switchboard, and the distribution panels, or centres of distribution, are assembled on Monson slate directly below the main switchboard, thoroughly enclosed in substantial iron cabinets fitted with hinged doors and locked. Between the floor of the main switchboard and the distribution cabinets there is a sloping chamber enclosed in sheet iron, with hinged covers, so arranged that any cable or group of cables may be pulled and examined without taking up the floor of the lighting gallery.

This is the first example of a dimmer board equipped with rod-drive dimmers. The connection between the dimmer-arm and the actuating lever is made by three-eighths-inch iron pipe. There are no live connections whatever on this main switchboard. On the secondary sub-panel the switches are mounted on one-inch

Monson slate. A diagrammatic view of this switch connection is shown in Fig. 4. This demonstrates the operating positions of the switch lever, which consists principally of two toggle-joints connected together by an insulating joint in the centre. The switches used in this installation were made by the W. S. Hill Electric Company.

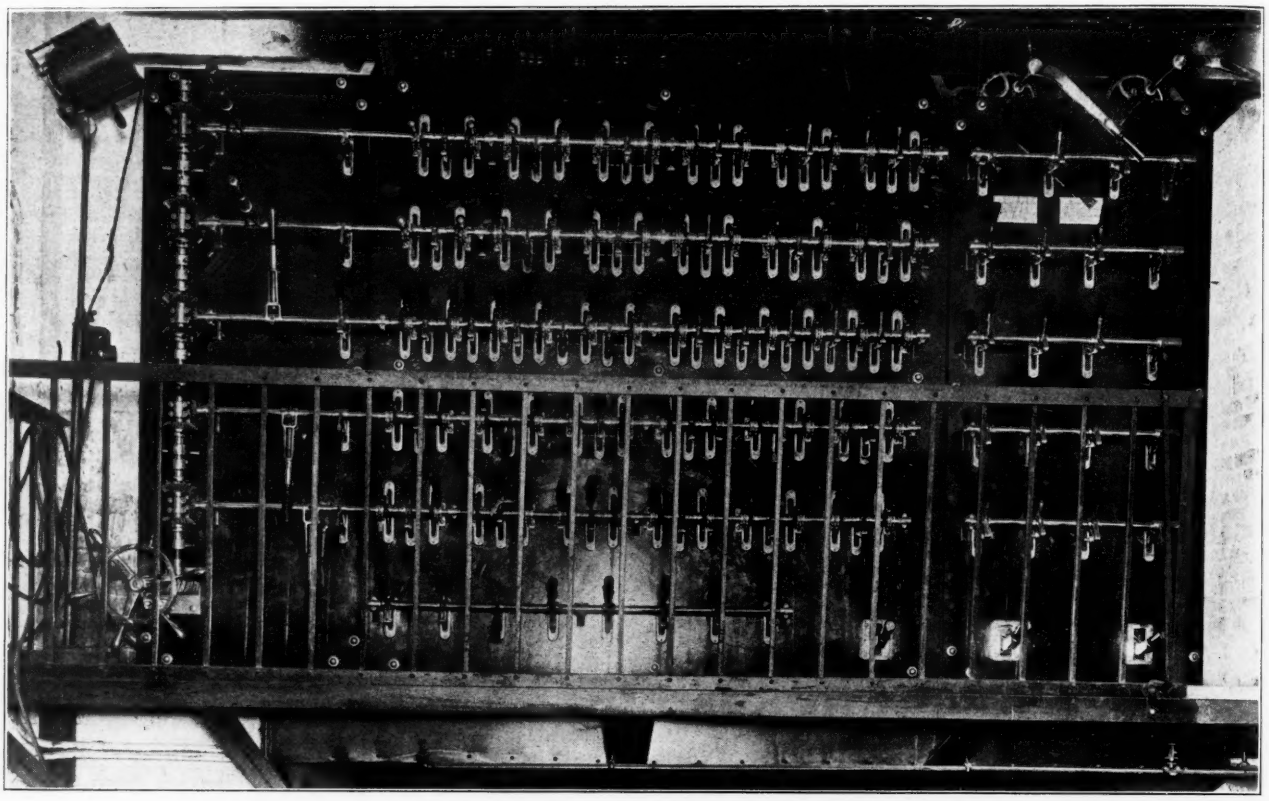


Fig. 2.—Main Distribution and Dimmer Board.

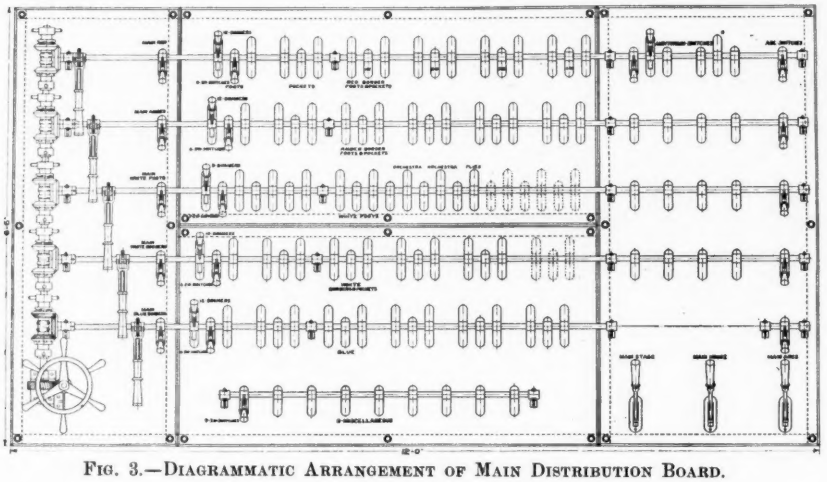


Fig. 3.—Diagrammatic Arrangement of Main Distribution Board.

As may be seen from the illustration, showing the front of the main board, the dimmer shaft may be worked from a master controller equipped so that any shaft may be operated either forward or reverse. The master controller shaft meshes in a worm gear and turns the dimmer shafts by means of beveled-gear connections. The diagram (Fig. 3) shows how the master controller shaft may be locked on either side of the dimmer shaft.

Referring again to Fig. 3, the scheme of connections may be understood. At the extreme left the main switches, when thrown, excite the bus-bar for each individual dimmer and switch section. The switch and dimmer handles corresponding to each section are arranged with a spring interlocking device which makes it possible to bring the lamps up to any degree of intensity and keep them at this point, irrespective of the further rotation of the dimmer shaft; or the dimmer handles may be set in certain positions and arranged to trip in, and all come up or all change simultaneously. Another feature of the interlocking arrangement prevents the dimmer handles from over-traveling. Each dimmer handle is provided with a roller bearing in the yoke between the two meshing contacts, which rotates upon an eccentric fastened to the board. As the movement of the dimmer shaft brings the dimmer handle up to the completion of its travel, it is thrown out of mesh with the dimmer shaft, and any other scheme of lighting which it may be necessary to carry out from this dimmer shaft may go on without reference to the dimmer handle which has completed its travel.

At the lower right-hand end of the board the main switches are located. The main arc switch, the main house switch and the main stage switch have each a capacity of 1,000 amperes. This switchboard was designed and built by James S. Pennefather, 105 West Thirty-ninth street, New York city, and is an example

of the most modern theatrical switchboard construction.

From the main switchboard separate circuits are carried to eighty-eight stage pockets, to a number of distributing panels, to the pockets on the lighting bridges, the fly galleries, and the footlights and border lights and strip lights. There are five strip or border lights, each equipped with sixty-five white lamps, sixty-five red lamps, seventy-five blue lamps and sixty-five amber lamps, all of thirty-two candle-power. There is also a large panorama border in semicircular form, containing 220 thirty-two-candle-power lamps. The footlights contain seventy white lights arranged in seven circuits. Any section of the white light can be cut in to reveal any particular part of the stage. There are also sixty-five red, seventy-two blue and sixty-six amber lamps in the footlight section, all of thirty-two candle-power. The white lamps are all in the bottom row, and the other colored lamps are in two rows, staggered so as not to interfere with each other. The lamps are wired through iron conduit, and "Federal" receptacles are installed in two-gang iron boxes with covers of special design to meet the latest underwriters' rules. Each individual circuit runs through a large wiring steel gutter located underneath the apron of the stage, this gutter being equipped with sliding covers, so that any fault may be easily located.

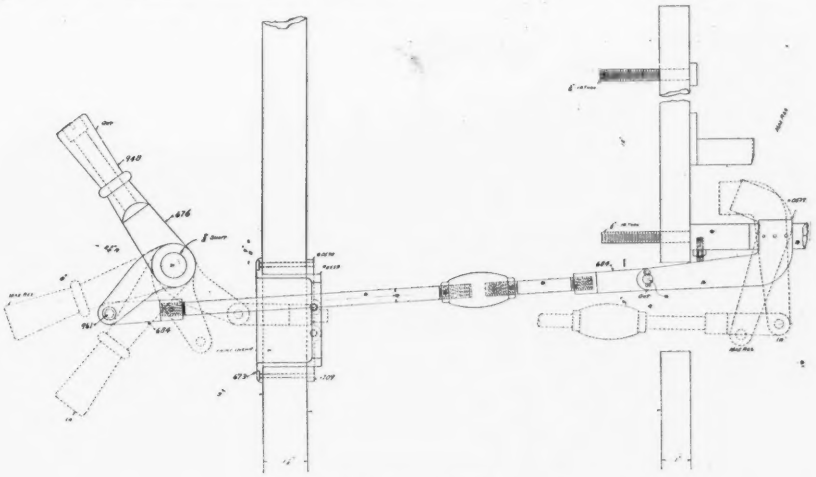


FIG. 4.—LEVER ARM AND SWITCH.

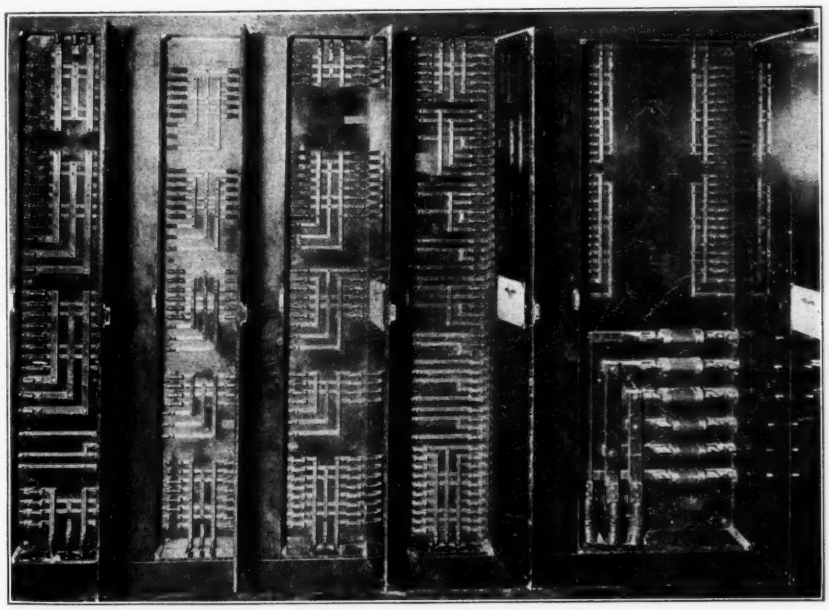


FIG. 5.—DISTRIBUTION CABINET.

The strip or border lights are supplied by forty-eight strand No. 12 B. & S. conductors. These conductors are bunched in the cable and a fire-resisting braided covering is placed around all. This cable runs from the centre of distribution below the main switchboard up to the gridiron at the top of the fly gallery, across the grid to a position from which it drops straight down to the end of its particular border. By a system of looping the cables over a special cradle, all slack is constantly taken up and the cable is allowed to follow the movement of the border. In changing the position of a border, all that is necessary is for the gripman to pull the proper cable whip, the conductor and border system being so counterweighted that it automatically takes care of itself.

In wiring the border lights the three-wire-system of distribution is used. In each of the outside wires a dimmer is introduced, these outside wires going to each half of the border circuit. The neutral is run straight through and connected to the middle point of the border circuit. In this way, by a proper manipulation of the dimmer handles, one-half of the border can be kept dark while the other half is being brought up or while any number of combinations are being effected with the different colored lamps in that half; or both halves of the border can be brought up again or alternated with any number of different combinations of the lights. The electrician in charge can set his dimmer handles for any arrangement or combination of lighting, and by operating the master controller can produce an indefinite number of combinations.

Separate feeders are run from the main distributing board to panels located in the hallways on each floor, which control the circuits for the dressing rooms. These circuits include make-up lamps and special outlets for bracket fans and electric curling-iron heaters.

There is also a large panel board in the box office which controls the lights for the exits, stairs, the marquise lights, the front-of-the-house sign, the attraction sign and eleven large standards on top of the marquise, the gallery and balcony signs, two large lanterns containing enclosed arc lamps and ten smaller bronze lanterns hung underneath the marquise, and the balcony and box-office entrances.

The auditorium lighting is arranged on eighteen separate controllers. The dome lighting is arranged so that one-half of the front may be controlled independently of the other half, and *vice versa*. In the dome there are forty-seven circuits running to forty-seven octagon-shaped panels built in the ceiling. Each of these panels is equipped with twelve incandescent lamps, and the panel is so arranged that the whole section is dropped on the end of a whip, carried on a windlass, to the floor for cleaning and relamping. The

circuits to the lamps terminate in a six-inch outlet box, and the connection to the feeder is made by means of a flexible connector and a two-pole fibre-mounted jack and plug. All the auditorium ceiling lights and the ceiling lights under the balconies and galleries are on separate circuits. The side lights for the balconies and the orchestra are also on separate circuits. There are a number of outlets provided for bracket fans and for ceiling "Gyrofans." The fans are all arranged on resistances, so that during the play the fans run at a slower speed, and consequently do not interfere with the work on the stage.

A feature of the stage work is a signal-box arranged with a series of push-buttons connecting with six stations. These push-buttons give the cues to the musicians' leader and gripmen, the men in the fly gallery and the electricians. As each push-button is pressed a signal shows in its proper place on the signal-board. This indicates that the same signal has been received at the distant point. If, for any cause, this signal should fail to work, there is a reserve speaking-tube service, and as an additional reserve, in case of emergency, there is a complete buzzer system to the various stations, this buzzer system also connecting with each dressing-room so as to notify the occupants of the time for raising the curtain.

Another feature of the stage work is a large platform elevator which rises flush with the stage and carries the properties to an intermediate level, and also to the level of the sub-basement floor. This greatly facilitates the removal of properties, and is quite an innovation in this work. The elevator is driven by an A. B. See twenty-five-horse-power electric elevator motor.

There is also a complete Stromberg-Carlson intercommunicating telephone system running to fifteen stations at present. The ultimate equipment of this service is for thirty-four stations. The telephone and buzzer systems are operated by means of a Holtzer-Cabot motor-generator set.

The auditorium lighting of the Stuyvesant Theatre is certainly unique. There has been a lavish expenditure of money and effort in order to produce a highly artistic effect. All the light comes into the auditorium from behind. Tiffany translucent glassware, inverted bowls, canopies and clusters being made use of. The decorative caps on top of the pilasters are utilized as sources of light, the whole cap-piece being molded with a Tiffany glass and bronze design. While this cuts down the intrinsic illumination very greatly, it is Mr. Belasco's idea that the lighting should be subdued as much as possible. The entire lighting scheme was carried out by the electrical contractors, Nimis & Nimis, 314 Madison avenue, New York city, under the direction of the architect, Mr. Keister.

THE DEVELOPMENT OF TURBO-GENERATORS.[1]

BY DR. ROBERT POHL.

Several most valuable and exhaustive papers have been recently read before this and other societies dealing with turbo-machines both for alternating current and direct current. The present paper is not intended to consider the whole of this vast subject, but is confined to direct-current generators. The paper will deal with these only, or at least mainly, from the point of view of their electro-magnetic design, in which, as is well known, the greatest obstacles to further improvement are encountered. The object is to show why certain outputs and speeds can not at the present time be safely exceeded, to define these output limits, and, in conclusion, to discuss briefly the directions in which further improvements may be expected. In this connection one or two suggestions will be made which may possibly prove to be of interest.

In view of the desirability—from the turbine maker's point of view—of running the set with as high a speed as possible, we have first of all to answer the questions: Given a certain diameter of the armature, which will be the maximum permissible speed at which it may be run, without undue stress being set up? and, secondly, What is the maximum possible output thereby obtainable, assuming the armature to be made axially as long as possible? In finding the reply to these questions we shall arrive at a curve showing the highest possible speed for which a generator can be built, as a function of its output.

In slow-speed machines the output, as is well known, is limited either by the sparking or by the heating. For the purpose of our present investigation, as may be particularly noted, we shall leave the question of temperature rise altogether out of consideration, because, though it requires the most careful attention in the design and construction, it can not be considered as an output limit. The extremely high periodicity and consequent large iron losses with which most turbo-generators have to work, coupled with their small dimensions, necessitate in most cases the employment of artificial cooling devices. A number of systems for artificial ventilation, which allow of the regulation of the quantity of air forced through, are in use, so that the heating limit can, for our purposes, be considered as lying above the output limit as fixed by other considerations.

The mechanical or speed limit of an armature is defined by the circumferential velocity, for which the tensile stresses reach their permissible limit. In working through modern turbo-generator designs it will be found that it is invariably the stress in the end shells protecting the connections which first approaches the limiting values. If we calculate the stress K occurring in an ordinary unloaded ring, of radius r cm., thickness δ cm., and specific weight γ, rotating with velocity v m./sec., we obtain:

$$K = \frac{1}{\delta} \int_{\phi=0}^{\phi=90} \frac{r \cdot d\phi \cdot \delta\gamma}{98.1} \times \frac{v^2}{r} \times \sin\phi = \frac{v^2 \cdot \gamma}{98.1} \text{ kg./sq. cm.,}$$

therefore the highest permissible velocity:

$$v_{\text{per m.}} = \sqrt{\frac{K_{\text{per m.}} \times 98.1}{\gamma}} = \sim 10 \sqrt{\frac{K_{\text{per m.}}}{\gamma}} \text{ m./sec.}$$

Allowing a permissible stress for ordinary bronze casting of 260 kilogrammes per square centimetre (tenacity about 1,500), we obtain as maximum velocity for an unloaded ring fifty-five m./sec. Considering the additional load due to the end connections, the maximum speed will only be about fifty m./sec. In order to allow of higher circumferential velocities, special phosphor-bronze and manganese-bronze castings are generally employed for the end shells. As the permissible stress for these materials is about 600 kilogrammes per square centimetre or even higher (tenacity about 3,500 to 4,500), the maximum velocity will be found to be seventy-five to eighty-five m./sec. under the conditions of load prevailing in such machines. If, for the purpose of our consideration, we assume seventy-five m./sec. to be the maximum circumferential velocity, we arrive immediately at the highest possible speed in revolutions per minute for any armature of given diameter.

Let us now proceed to the purely electrical output limits.

Flash-Over Limit—While in ordinary slow-speed direct-current machinery the only electrical limit is that of sparking, in high-speed machines we have not only to deal with this factor, but also with a new one, which we may term the "flash-over limit," and which requires quite as much attention as the commutation. In fact, not a few turbo-generators, in spite of their good commutating qualities, have

[1] Abstract of a paper read before the Institution of Electrical Engineers, London, England, November 28.

proved to be failures on account of their tendency to arc round the whole commutator. If one were to inquire from the designers as to the cause of this trouble, they would, in most cases, attribute it to insufficient insulation of the shrink-rings and of the brush gear. This may often have been the cause; so much is certain, however, that in not a few cases the real source of the trouble must be attributed to the excessive potential difference between two adjacent commutator bars.

It is, of course, a matter of common experience that bad commutation, particularly in connection with a dusty commutator, can by itself be the cause of flashing over, and it is further well known that the kind of winding employed and the velocity of load fluctuations, which result in momentary increases of pressure, materially influence the phenomenon. Whilst fully recognizing the importance of these subsidiary causes it must, in the author's opinion, be admitted that the maximum voltage per segment is the most important factor, which for satisfactory performance should not exceed a certain value. This value we shall have to decide upon. In doing so, however, it must be remembered that the circumferential velocity is already fixed as not more than seventy-five m./sec., and that now in limiting the voltage per segment, the highest number of lines of force which can be allowed to pass through the gap per centimetre of circumference is at the same time settled. In other words, by limiting $e_{s\,c\,g.\ max.}$ the product $B_{g\ max.} \times l_a$ is simultaneously limited, which practically means also the length of the armature.

Experience has shown that slow-speed machines, with clean commutators and the usual thickness of mica insulation between the segments, approach their flash-over limit if the voltage per segment reaches a maximum of about sixty volts. As a safe limit in the case of turbo-generators forty volts may be taken, the smaller figure taking into account the effect of load fluctuations, dust, etc. In testing and examining a large number of different machines the author found this figure only once or twice slightly exceeded. From $e_{s\,c\,g.\ max.}$ = forty volts and v = seventy-five m./sec. the product $B_{g\ max.} \times l_a$ is found to be:

$$B_{g\ max.} \times l_a = \frac{40 \times 10^8}{2 \times 75 \times 100} = 267{,}000.^1$$

[1] The armature winding is assumed throughout the paper to be an ordinary lap winding, for which the potential difference between two adjacent commutator bars is equal to the electromotive force induced in two conductors in series.

Assuming twenty-five per cent field distortion—

$$\left(\frac{B_{g\ max.}}{B_{g\ mean}} = 1.25\right)$$

then—

$$B_{g\ mean} \times l_a = 215{,}000,$$

which for $B_{g\ mean} = 5{,}000$ corresponds to l_a = forty-three centimetres as greatest permissible length of the armature, independent of its diameter. We now arrive at the total number of lines $p \times N$ (p = number of poles, N = flux per pole), entering or leaving the armature. Taking the ratio $\frac{\text{1 pole-arc}}{\text{pole-pitch}} = a = 0.65$,[1] we find $p\,N = d_a\,\pi\,a\,B_{g\ mean}\,l_a = 0.44\,d_a\,10^6$ (second column of Table 1). It will thus be seen that in the design of the magnetic circuit of a turbo-generator the flash-over limit is of the utmost importance, as it restricts the number of lines allowed to enter or leave an armature of given diameter.

Commutation Limit—The only point which now remains to be settled, before arriving at the highest possible output, is the question as to how many ampere-turns can be accommodated on the circumference of the armature, or, in other words, which is the highest permissible specific load A S (ampere conductors per centimetre armature circumference). The limiting factor in this case is the sparking. The quality of the commutation, of course, depends not only on the A S value of the armature, but is intimately connected with quite a number of other electric and magnetic conditions, particularly the effectiveness of the commutating poles. Last, and not least, it depends greatly on the mechanical conditions of the armature, the commutator and the brushes. Further, in machines of large output, the pressure, or better, the absolute value of the current strength, is of the greatest importance, so that for 550-volt machines A S may be considerably higher than for 240 or even 120-volt machines. Although a general fixing of A S values is therefore impossible, a curve, applicable to well-designed 550-volt machines, working with the above-stated values of v and d_a, may be adopted as containing the limiting figures. Having thus settled upon the values of A S, $p \times N$, and the speed, the maximum possible output in kilowatts for any assumed diameter can now easily be deduced.

As the electromotive force produced by a generator is:

$$E = p\,N \times \frac{s}{a} \times \frac{n}{60} \times 10^{-8},$$

[1] For reasons of leakage and core density a is usually much smaller than in ordinary machines.

and the current strength:

$$C = A\,S \times d_a\,\pi \times \frac{a}{s},$$

the output will be:

$$K.w. = \frac{E \times C}{1{,}000} = p\,N \times A\,S \times d_a\,\pi\,\frac{n}{60} \times 10^{-11}.$$

The following table, based on the above calculation, shows the maximum outputs and speeds which at the present time are obtainable in the very best designs:

TABLE I.

d_a in Centimetres.	N. for v = 75 m./sec.	$p\,N \times 10^{-6}$	A.S.	Output in Kilowatts.
30	4,780	13.1	150	148
40	3,590	17.6	185	244
50	2,870	22.0	210	347
60	2,390	26.3	230	454
80	1,800	35.1	255	670
100	1,435	44.0	270	890
120	1,195	52.9	280	1,110
140	1,020	61.5	290	1,340
160	895	70.2	300	1.585
200	720	88.0	315	2,080

Up to about 500 kilowatts a dynamo can be built to the requirements, whilst for outputs above 500 kilowatts, the proper domain of the steam turbine, it is not possible to construct direct-current generators running at so high a speed as the equivalent turbine demands.

There are two ways of overcoming the discrepancy. The one consists in artificially reducing the speed of the steam turbine, which, however, is connected with increased cost and steam consumption; the second is the tandem arrangement of two dynamos coupled to one turbine, the capacity of each being one-half of the turbine output.

The latter method obviously brings the dynamo well within the above calculated limits, and it also has certain practical advantages. It adds, however, considerably to the cost of the set, involves further expenses in foundations, bearings, etc., and increases the floor space required. Both methods can, therefore, only be considered as temporary measures. Considering further the growing demand for large units, the endeavor of all manufacturers of turbo-generators to extend the output limits appears to be fully justified. In fact the problem is perhaps even more important than might appear from the above consideration, seeing that the successful production of direct-current turbo-generators suitable for much higher speeds than was hitherto possible, would further reduce the steam consumption, and considerably lower the output, for which the turbine becomes superior in performance and in first cost to the reciprocating engine. It would also exercise great influ-

ence on the choice of a system for central stations and power-transmission schemes.

Let us consider in which directions such further improvements may possibly be accomplished.

Homopolar Machines — Before dealing with methods for the reduction of the electrical difficulties in commutating machines, it will be of interest to consider the prospects of the now well-known homopolar type of direct-current dynamo. Though historically the oldest electromagnetic generator, this type had been almost forgotten, until in 1904 the publication of the test results and of the construction of a 300-kilowatt homopolar turbo-dynamo, built by the General Electric Company, Schenectady, N. Y., directed the universal interest again to the same. Since that time, however, so far as the author is aware, no further experimental results of homopolar machines have been published, although the patent records indicate considerable activity in the direction.

The main and somewhat threadbare objection cited against the homopolar principle is the difficulty of obtaining sufficiently high voltages. The author ventures to suggest, however, that this is not the most important one, but that the excessive weight of active material, which these machines require, is, from a commercial point of view, practically prohibitive. Returning, however, first of all to the production of high voltages, the belief has often been expressed that the development of high-speed prime-movers would greatly facilitate the introduction of the homopolar machines on the ground that turbo-speeds would remove the long-standing objection against this type. It may be pointed out that this argument must be taken with great reserve. In fact, it is easy to show that exactly the opposite is the case, provided that in all cases the same circumferential velocity of the armature is allowed. The poor utilization of the material in homopolar machines is mainly due to the low A S values, which are approximately only one-tenth of those employed in large commutating machines. We necessarily arrive, therefore, at approximately ten times the weight of magnetic material. Seeing that the A S value is limited by the brush apparatus, the problem of building a commercially successful homopolar machine appears to be identical with the problem of constructing a reliable apparatus for taking current out of a cylinder rotating at very high velocity with a current density corresponding to about 200 to 300 amperes per centimetre of circumference. So long as this problem remains unsolved the homopolar machine seems to be only suitable for such outputs and such low pressures for which a commutating machine is practically impossible. The solution of the problem, however, is perhaps connected with even greater difficulties than those involved in the further improvement of commutating machines.

Means for the Improvement and Increase of Output of Commutating Machines—Such means must have for their object the further extension of the above discussed two limits, namely, the sparking and the flash-over limit. This can be accomplished, first, by working with a higher circumferential velocity of the armature. Considering two machines of equal output and speed, of which one has the armature diameter D, the other the diameter 2D, the length of the armature of the second will be only a quarter of that of the first, whilst for the same pressure the number of conductors and segments will be doubled. The voltage per segment, and approximately also the reactance voltage, will therefore only be one-half of the respective values of the first machine. These two voltages may be taken as being approximately inversely proportional to the circumferential velocity employed. Now 75 m./sec. can not very well be exceeded with ordinary manganese-bronze or phosphor-bronze castings for the end shields. By employing, however, certain steel alloys of very low magnetic conductivity and high tensile strength, further progress in this direction appears to be possible. The difficulties connected with balancing, which rapidly increase with increase of circumferential velocity, must, however, not be disregarded. Even more important than the first balancing is the steady running and maintenance of balance under continuous work. It is therefore infinitely preferable to aim at such further improvements which do not entail any further increase in the velocity.

Directing our attention to the permissible A S values, a further possibility seems to lie in the careful adjustment of the commutating field. This would have for its object the extension of the A S line without exceeding the sparking limit. As is well known, in machines with artificial commutation additional short-circuit currents and sparking can only occur if the electromotive force induced by the commutating field is different from the reactance voltage. Now as the latter increases exactly in proportion to the armature current, the characteristic of the commutating field should be exactly a straight line. Unfortunately this is not the case, and, in fact, it is mainly the deviation from this straight line which ultimately causes sparking and limits the permissible A S. Even for the very low saturations obtaining in the commutating poles of turbo-generators the characteristic of the commutating field is slightly convex instead of being exactly straight.

The author has found that the following method allows an adjustment of the form of the characteristic. A shunt parallel to the commutating poles is employed, the resistance of which increases rapidly with increasing load. Iron resistances of the kind used for Nernst lamps are particularly suitable, although thin copper wires may also be employed, for which, without enclosure in an air-tight bulb, high temperatures may be permitted. As will easily be seen, the ampere-turns of the commutating poles as a function of the load will now rise according to a concave curve, thus compensating for the curvature of the characteristic. Experiments have shown that almost exact straight-line relationship between the intensity of the commutating field and the load is thus obtainable within very wide limits.

Coming finally to the flash-over limit, the possibility might be suggested of improving the commutator construction with the view of preventing flashing over. This would permit of a higher voltage per segment, and would enable us to work with a larger magnetic flux and thus to increase the output. It must not be forgotten, however, that even if this were possible, an increase of the output by means of larger flux is, in principle, connected with a lengthening of the armature, and means, therefore, at the same time an increase of the reactance voltage and of the commutation difficulties. Thus, what might be gained in flux would at least partly be lost in A S.

There is no likelihood of decided improvements in the direction of increased flux unless means are found which would enable the armature to be lengthened without exceeding the flash-over limit and simultaneously without increasing the reactance voltage. This can only be accomplished, it seems, by a suitable arma-

ture winding, and the author believes that it is in this direction that important developments must be looked for.

A brief description of a new winding which has the above aim for its object may be permitted, although no experimental results can as yet be communicated.

In machines working in the near proximity of the above-calculated limit the number of commutator segments is in most cases extremely small, and the width great. Leaving out of consideration multiple windings, which in practice have proved unreliable, it is impossible to increase the number of segments, as this would cause a proportionate rise of A S and of the reactance voltage. It has been repeatedly proposed to adopt additional segments connected to suitable points of the armature coils, and to increase thereby the number of bars without increasing at the same time the A S value. The intention is to commutate each coil step by step and to obtain a reduction of both the reactance voltage and of the voltage per segment.

There is no doubt that the voltage per segment is actually halved. As regards the commutation, however, it will be found, on closer examination, that the reactance voltage is by no means necessarily reduced, because the self-induction of the connecting wires always adds itself to that of the conductors undergoing commutation. In practice the connectors will be necessarily arranged in holes in the armature iron. They are surrounded entirely by magnetic material, and the self-induction of a connecting wire will most likely be far higher than that of a conductor. Assume, for sake of argument, that practically no current at all would pass through the connecting wires to the commutator, owing to their very high self-induction. Then the reactance voltage would be twice as great as in any ordinary winding, as the time of commutation would be reduced to a half. If, on the other hand, the resistance and the self-induction of the connecting wires would be similar to that of the ordinary commutator lugs, the reactance voltage would be halved. From this it is seen that whether the auxiliary segments improve the commutation or otherwise depends entirely on the self-induction of the connectors. Now, there is a simple way for the neutralization of their self-induction. If they are arranged in groups in such a way as to have connectors of opposite polarity always in close proximity to each other, so that the number of ampere conductors in every one of these groups is always zero, practically no lines of force will then be interlinked with any such group. Their self-induction is thus eliminated. This will be more clearly understood by considering a bipolar machine in which all the connectors are arranged in one group—for instance, in a hollow shaft. At any instant the connecting wires will carry exactly the same amount of current in both directions, so that no change of magnetic flux can take place. In the practical construction of this winding it is by no means necessary to make the number of groups equal to the number of pairs of poles, although in four and six-pole machines this does not create any great difficulty. The number of groups may be made as large as convenient, if only care be taken to have in each group wires which are displaced by 180 electrical degrees. The objection could be made that there will always be irregularities in the distribution of the current and induction effects due to the same. To prevent irregularities as completely as possible, the connectors are joined to equalizing rings at the back of the armature, and, furthermore, they are arranged in copper tubes through the armature core, which would exercise a very strong damping effect on any remaining magnetic oscillations. The connectors are made of considerable size, so as to keep the ohmic resistance as low as that of the ordinary commutator lugs. Satisfactory running machines of twice the present armature length, and of twice the output at present obtainable, appear to be within the possibilities of this winding. The necessity of arranging two machines in tandem would thereby be removed, and even for such outputs and speeds which at present can be obtained by means of one machine only the application of the new winding should mean a very great margin of safety as to sparking and flashing over. Such results, however, would, probably, by no means form the limit of what may be expected from the future as regards direct-current turbo-generators. We are only in the very beginning of their history, and, in spite of some reverses, the great progress made during the last few years justifies the confident expectation of much more important developments.

Ithaca Section of the American Institute of Electrical Engineers.

The regular meeting of the Ithaca section of the American Institute of Electrical Engineers was held in Sibley College, Cornell University, on Friday evening, December 6. An audience of 273 greeted the speaker, W. N. Smith, electric traction engineer, Westinghouse, Church, Kerr & Company. Mr. Smith's paper was the first formal Institute paper presented before this section, and it was entitled, "Practical Aspects of Steam-Railway Electrification," an outline of which follows:

A tentative classification of steam-railroad electrification problems was first proposed, and electrification projects were examined: (1) from the standpoint of electrification; (2) from that of railroad operation.

Under the first head the relationship of the manager and the consulting engineer was discussed. Under the second head was discussed the relationship of the financial or economic, the engineering, the construction and the transportation or operative subdivisions of railroad operation.

Particular attention was paid to the matter of single-track railroad operation, from the standpoint of capacity from train movement.

The treatment was suggestive rather than dogmatic as to actual performances, and intended to direct attention toward defining the limitations of single-track operation, and allowing for the effect of block signaling rather than attempting to prescribe wholesale electrification as a means of increasing the capacity of railroad tracks for train movement.

In the discussion Professor H. W. Hibbard, head of the Railway Mechanical Engineering Department of Cornell University, expressed his appreciation of Mr. Smith's treatment of the problem. He felt that, to a certain extent, the steam-railroad man had been ignored in the electrification problem. He emphasized that there is no antagonism to electrification on the part of steam-railroad men, where the conditions seem to warrant its introduction. He did not feel, however, that electrification should be forced upon steam railroads, but rather that it should be adopted when conditions fully warrant such adoption. The steam-railroad man is first and foremost a transportation engineeer, regardless of the source of motive power.

Professor V. Karapetoff discussed the problem from the standpoint of power supply.

EXPERIMENTAL DATA ON ILLUMINATING VALUES.[1]

BY CLAYTON H. SHARP AND PRESTON S. MILLAR.

The subject matter which forms the basis for this paper has kindly been placed at our disposal by the Lamp Committee of the Association of Edison Illuminating Companies. The tests herein described have been made at the instance of the Lamp Committee, for the purpose of presenting data which will be useful to engineers in connection with their work in planning or managing illumination installations. They are preliminary tests only and bear chiefly upon the illuminating efficiencies of various electric illuminants and upon the effects on such efficiencies of varying arrangement and equipment of the lamps used in them.

By a very fortunate circumstance, a room was available for the purpose of this test, which possesses peculiar advantages for this purpose. This is the auditorium of the New York Edison Company. From a technical point of view, this room is particularly well adapted to the purpose, since it is located under the same roof with the laboratory and substation of the Edison company. The storage battery of the substation was available as a source of steady current supply, and the resources of the laboratory were kindly placed at the disposal of those making the test.

This auditorium is equipped with a cove-lighting installation and with an arrangement of ceiling-lamps and side-brackets, all conveniently controlled from a panel-board. The Edison company undertook the work of arranging such temporary installations as were required for the purpose of the test. These installations were selected at the suggestion of the advisory committee in such a way as: first, to bring out the relative illumination efficiencies obtainable with similar illuminants, variously arranged and variously equipped with reflectors, etc.; second, to give a basis for reliable comparisons of the illuminating efficiencies of illuminants of different types.

The fact should be emphasized, however, that the results here given apply in all strictness only to the room in question, and that in using these data in connection with other installations, proper consideration should be given to this fact.

In making these tests and in arranging the installations, the purpose for which the room was originally designed was in some cases entirely neglected. It was considered as a space which might be a workshop or an office, instead of an auditorium. The special requirements, therefore, of auditorium lighting were not given any weight whatever in many of the tests. In Fig. 1 is seen a vertical section of the room, drawn to scale. In the table which follows is given a condensed description of the various installations upon which tests were made.

The sixteen candle-power carbon incandescent lamps which were used in the installations requiring such lamps, were new lamps, taken from a package which had been purchased recently subject to the inspections of the Electrical Testing Laboratories, and which could therefore be considered as well-rated lamps. These lamps were burned about fifty hours before the first test was undertaken. The frosted lamps were selected in a similar manner. The actual candle-power and watts of these lamps were determined by selecting a considerable number of representative ones and photometering them in the laboratory, at the actual voltages used in the tests. The deterioration of these test lamps in successive tests was also determined in this way.

With these installations the measurements which could be made in the limited time available consisted in: first, a determination of the candle-power and efficiency of the lamps; second, a determination of the illumination produced by the various installations and the electrical power required in each case.

The immediate results which can be derived from these tests are comparative data on the illumination produced and on the illumination produced per watt, and also a determination of the uniformity of the illumination. It is desirable, also, to know what ratio of the total light which is emitted by the lamps in a room may be expected to fall on a plane of reference, *i. e.*, the horizontal plane on which measurements of the intensity of the illumination are commonly made. This ratio of the light generated to the light utilized on the plane of reference gives a value for the net efficiency of the installation. However, in order to arrive at an expression for this efficiency, it is necessary to employ some unit in which the total light from the lamps and the total light falling on the plane of reference can be expressed. For this purpose the notion of the flux of light is used, and the unit in which luminous flux is measured is introduced. This unit is the "lumen," which is defined as the flux of light emitted by a source of one candle-power in a unit solid angle. The total luminous flux from a source of light is equal to 4π, or 12.57 times its mean spherical candle-power. We can measure in lumens not only the output of the lamps, but also the flux of light through the plane of reference, and the ratio of the lumens through the plane of reference to the lumens yielded by the lamps, gives the net efficiency of the installation. In a similar way the efficiency of the lamps may be measured by their lumens per watt; and the gross efficiency of the illumination installation can be measured by the lumens on the plane of reference per watt expended in the lamp. The lumens on the plane of reference are determined by multiplying the intensity of illumination on this plane, as expressed in candle-feet, by the area of the plane in square feet, *i. e.*, the flux through a plane is equal to the intensity of the illumination on the plane multiplied by the area of the plane, or the illumination on the plane is equal to the density flux of the light falling on that plane. These considerations make it possible to draw certain conclusions from the data at hand,

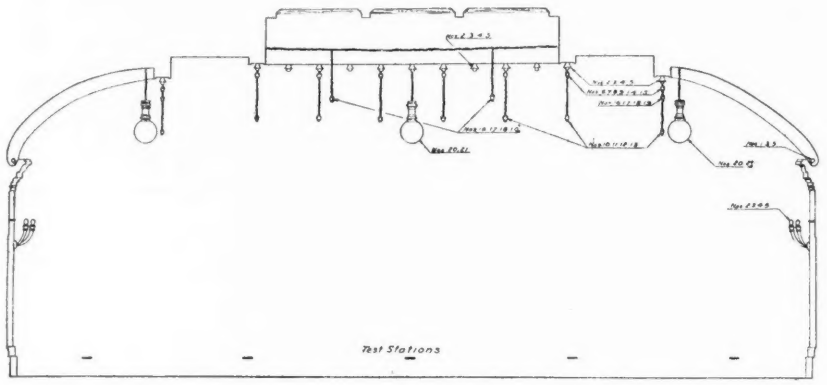


FIG. 1.—VERTICAL SECTION OF AUDITORIUM WHERE THE MEASUREMENTS WERE MADE, SHOWING THE ARRANGEMENTS OF THE VARIOUS TYPES OF INSTALLATION.

[1] Condensed from a paper read at the recent convention of the Association of Edison Illuminating Companies.

which are of general availability in illumination problems, and which could scarcely be deduced without the consideration of such terms as have been employed in this paper.

In order, therefore, to determine these quantities it has been necessary, as intimated above, to determine the actual candle-power of the lamps under service conditions, and this has been done by a careful measurement of the voltage of the line and laboratory photometric tests of representative lamps, at the measured voltage. From these data the mean spherical candle-power of the lamps is determined, and hence their output in lumens. We wish to take this occasion to emphasize the importance in connection with every illumination test, of determining the actual luminous output under service conditions of the illuminants used. Not only does this procedure enable certain general conclusions to be drawn from the tests, but it also helps to locate definitely the responsibility for any excess or deficiency in the measured illumination. It tells something about what the actual conditions of the operations of the illumination plant are, and enables conclusions to be drawn as to the illumination obtained under average working conditions. For instance, as will be seen further on in the paper, the lamps used in this test, although carefully selected new lamps, were giving much less than sixteen candle-power in nearly all cases. For this condition of affairs the voltage drop on the lighting wiring was largely responsible; and the reason for the variations in the candle-power of the lamps is to be sought in the varying voltage drops on the wiring, much of which was installed only for temporary use. These variations having been found under conditions where the uniformity and accurate rating of the lamps had been attended to, it is possible only to speculate on what may be the conditions in actual installations, where the lamps are of various qualities and various ages. It is necessary, therefore, in order to make a completely satisfactory illumination test of any installation, to determine, as has been said, the luminous output of the lamps under their actual condition of employment.

The question of the proper instrument and method for the measurement of the illumination has been gone into with very great care. Three different instruments have been used in our measurements, all of which are designed so as to reduce the unavoidable errors to a minimum, and have been operated with all due consideration to the elimination of errors and to the ultimate accuracy of the results obtained.

In measuring the illumination, forty-five stations were selected, equally spaced over the floor of the auditorium. These measurements resulted in a very great mass of data, in order to handle which comprehensively required the use of special methods. This has been done by plotting the values of illumination on a map of the floor area, and then connecting by lines all points having the same illumination. This gives a set of lines which we have called *equilucial lines,* by analogy with equipotential lines of an electrostatic or a magnetic field. The simplest and most obvious properties of equilucial lines are that lines of different value can never intersect, and that the lines will, in general, be closed curves, except where they meet the walls of the room. If the lines are plotted representing in all cases the same percentage variation of illumination, the closeness of the lines to each other represents the illumination gradient, or the rate at which the illumination is changing from place to place on the plane of reference, and consequently the lack of uniformity in the illumination. It follows, therefore, that in a diagram where the lines are spaced far apart, the illumination is uniform, and where they are close together, and many of them are shown, the opposite state of affairs obtains. Diagrams of this character have been prepared for the various tests which have been made, and permit of ready study of the results obtained.

A number of such diagrams are given in Fig. 2. These, in each case, show the arrangement of the lamps and a condensed description of the type of installation is given.

In tabulating the results of the tests, the maximum, the minimum, and the average values of the illumination have been given in each case. From these values, taken in connection with the candle-power of the lamps, their mean spherical candle-power, and their watts per spherical candle-power, various results have been obtained, the true value of which can be developed only by a close and critical study, and which it is impossible to discuss within the limits of this paper.

In a general way the tests made were in-

	INSTALLATION				Test No.	EQUIPMENT				PHOTOMETRIC DATA					ILLUMINATION VALUES FOOT CANDLES					LAMPS	EFFICIENCY VALUES ILLUMINATION	
			No. of Lamps	Height From Floor		Border	Centre	Cove and Brackets	Reflector	No. of Lamps	Avg. M.H.cp	Avg. M.S.cp	Watts per M.H.cp	Watts per M.S.cp	Total Watts	Max	Min	Mean	Variation	32°	Lumens per Watt	Gross Lumens Effective per Watt	Net Lumens Effective per Lumen Generated
A	Permanent Installation, 16 cp Lamps	Cove	121	10'- 8"	1			Clear		121	16 28	13 42	3 08	3 73	6210	2 27	1 11	1 72	29 7%	1 48	3 34	0 9	23 7%
		Brackets	42	8'- 0"	2	Clear	Clear	Clear		244	11 8	12 2	3 26	3 95	11600	7 10	3 92	6 18	25 7%	5 52	3 16	1 54	43 8%
		Border	104	14' 10"	3	Clear	Clear	Clear		365	14 05	11 50	3 38	4 05	17300	8 41	5 60	7 56	24 9%	6 72	3 01	1 265	41 9%
	Oval Anchored	Centre	98	15'- 0"	4	Frosted	Frosted	Frosted		244	13 86	11 41	3 48	4 36	11930	6 53	3 70	5 65	25 1%	5 07	2 9	1 265	47 3%
B	16 cp Lamps Suspended From Alternate Sockets				5	Frosted	Frosted	Clear Frosted		365					17760	8 00	5 57	7 23	16 85%	6 42	3 03	1 18	39 0%
					6	All	All	No		100	15 5	12 78	3 12	3 84	4910	3 80	1 98	3 20	28 5%		3 28	1 01	58 2%
		Centre	52	14'- 9"	7	Lamps	Lamps	Side	Holophane Concentrating	100	15 33	12 64	3 22	3 89	4920	5 47	2 08	4 07	36 8%		3 13	2 35	72 7%
		Border	48	14'- 1"	8	Clear	Clear	Lights	Holophane Diffusing	100	15 17	12 5	3 26	3 95	4940	5 16	2 08	4 02	38 3%		3 19	2 31	72 6%
					9				Mirrored Concentrating	100	15 43	12 71	3 17	3 85	4930	7 69	1 50	4 92	62 9%		3 26	2 86	87 7%
					10	All	All	No		100	16 11	13 28	3 06	3 72	4940	9 15	2 38	5 50	25 3%		3 38	2 02	59 8%
C	Same at Different Height	Centre	52	12'- 6"	11	Lamps	Lamps	Side	Holophane Concentrating	100	13 72	12 13	3 30	4 0	4865	5 83	1 85	3 94	59 9%		3 13	2 30	73 9%
		Border	48	11'-10"	12	Clear	Clear	Light	Holophane Diffusing	100	15 4	12 69	3 22	3 9	4951	5 92	1 91	4 28	46 9%		3 22	2 46	76 4%
D	Same Lamps				13				Mirrored Concentrating	100	15 33	12 63	3 19	3 87	4902	6 20	1 12	4 45	72 9%		3 25	2 59	79 6%
		Centre	38	14'- 9"	14	Clear	Clear	Clear	Mirrored Pendent Concentrating	98	14 9	12 28	3 29	3 99	4798	7 07	83		66 4%	24 70	3 76	2 79	88 3%
		Border	48	14'- 1"																			
		Brackets	12	8'- 0"	15	Clear	Clear	Clear	Mirrored Tilted Concentrating	94	15 25	12 58	3 19	3 87	4775	6 82	64		70 9%	3 92	3 20	2 33	73 9%
	No 16. GEM					GEM Frosted Tip	GEM Frosted Tip	Border Centre	Holophane Bowl Holophane Concentrating	24	30 1	32 9	2 67	3 14	4328								
					16						105 8	87 8	2 43	2 93		4 61	2 08	3 33	37 8%		4 21	2 9	52 2%
		Centre	12	13'- 5"	17	Tungsten Clear	Tungsten Clear		Holophane Bowl	24	79 3	63 4	1 19	1 49	1694	4 75	1 88	3 29	30 2%		3 10	5 52	65 2%
		Border	12	12'- 5"																			
E	No 17. Tungsten																						
	Nos. 18 and 19, Nernst	Centre	12	13'-	18	Opal	Opal			24		37 0		3 15	2092	3 08	1 14	2 09	46 4%		3 08	2 12	53 2%
		Border	12	13'-	19	Opal	Opal Concentric	Diffuser	Holophane Diffusing	24		36 9		3 16	2706	3 55	93	2 24	58 6%		3 04	2 28	57 3%
						38°			Outer Alabaster Reflector Inner Clear														
F	5 Ampere Enclosed D. C. Arc		9	12'- 5"	20					9		22 9		2 7	4524	7 88	2 07	4 31	67 5%		4 54	3 22	68 9%
								Alabaster Globe Outer Clear Inner															
					21					9		22 9		2 7	5530	6 46	1 73	4 01	58 6%		4 54	3 06	65 2%

tended to show, first, the comparison between the various permanent installations in the auditorium; second, the increase in illumination efficiency resulting from equipping the ceiling lamps with various reflectors, and the effect of using frosted instead of clear bulb lamps; third, the effect of lowering the same equipment to a point nearer the floor. Furthermore, Gem lamps, tungsten lamps, Nernst lamps and arc lamps were installed, with the idea of obtaining comparative data on their illuminating values as used in a room of the dimensions and characteristics of this auditorium. These varying results are summarized in the accompanying table.

The matters of particular interest in this table are the efficiency values which are shown in the concluding portion. In the first column are given the lamp efficiencies correctly expressed in terms of total flux of light per watt, or lumens per watt. The next column shows the gross efficiency of the illumination installation, or the lumens which fall on the plane of reference per watt expended in the lamps. This is the efficiency which most interests lamp users; it forms a measure of the economy of their lighting installations, and depends not only upon the economy of the lamps, but upon the proper arrangement of the lamps in the room and the judicious selection of reflectors, etc., used with them. To reach its maximum value, the lamps must represent the best skill of the lamp engineer, and their arrangement and equipment the best skill of the illuminating engineer.

By a comparison of the lumens which become effective on the plane of reference, with the lumens which are generated by the lamps, we get a value for the net efficiency of the installation. The value of this efficiency indicates the degree of skill with which the installation has been planned and carried out. It is totally unaffected by the efficiency of the lamps employed and refers only to the illumination installation as such, irrespective of the illuminants used. It is, however, largely affected by the character of the room which is illuminated, as is also the gross efficiency of the installation. Walls and ceilings finished in light, highly reflecting colors produce a very large increase in the illuminating efficiency as compared with what is obtained when these are of sombre hues. Consequently, while the values for gross and net efficiencies given in this paper may be applied without many misgivings to rooms of similar dimensions to the auditorium and which, like it, have highly reflecting walls and ceilings, yet they may have to be divided in half in the case of an installation in a room in which the walls have a highly absorptive character.

As to the usefulness of these terms, we may note that if the illuminating engineer, by a study of these and similar data and from the results of his own experience, is able to form a reasonably correct estimate of the net efficiency to be expected with a given installation, he can tell with the greatest facility the number of lamps required to produce the required illumination. This constitutes a very facile shortcut in the computations of illumination engineering.

Coming next to a consideration of the actual results obtained, we notice that in the case of the cove lighting, less than one-fourth of the light actually generated is effective in illuminating the plane of reference, whereas when the ceiling and bracket lamps are used nearly one-half of the light is effective. One watt expended in the cove lamps gives only 0.8 lumen effective; whereas, with the other lamps it gives nearly twice as much. Added to the inefficiency of the cove lighting we have the further disadvantage that the ceiling of the room is illuminated to a very high degree, and this high illumination, reacting on the eye, causes it to demand a higher degree of illumination on the working plane than would otherwise be required. For purposes of effective seeing, the bright ceiling is a distinct disadvantage. The use of frosted lamps cuts down the efficiency of the ceiling and border lighting installation from 48.6 per cent to 47.02 per cent, or only about three per cent. Taken by itself, this is a negligible decrease, in view of the better effect of the frosted lamps on the eye. However, the more rapid decrease in candle-power of the frosted lamps must be taken into account in comparing these two installations.

Coming next to a consideration of the effect of reflectors, we notice that the lamp installation on which reflectors were to be tried had to be lowered a short distance from the ceiling on account of the character of the plaster rosettes used in the permanent installation. Bringing the lamps out of these rosettes resulted in an increase of twenty per cent in the net efficiency. Equipping these lamps with Holophane prismatic reflectors brought the efficiency of the installation up from fifty-eight per cent to seventy-three per cent, the effect of the concentrating and of the diffusing reflectors being practically the same. These values, however, are much exceeded by those obtained by the use of the so-called X-ray reflectors—opaque reflectors, silvered on the inside. Using these reflectors, eighty-nine per cent of all the light generated by the lamps was thrown on the plane of reference. This is indeed highly efficient lighting, provided that all that is wanted is a maximum of illumination on a horizontal plane thirty inches from the floor. Necessarily with this installation the brilliancy of the walls and ceiling was very much reduced, since much light which in other installations was thrown on to these parts was concentrated on the floor. For many purposes this would be a highly desirable form of illumination; while for other purposes the illumination produced by the glass reflectors, while showing on test a lower efficiency, would be more desirable.

A further test with incandescent lamps was made by lowering the whole installation to a point two feet three inches nearer the floor. This did not in any case result in a marked increase in the illumination. In the case of the X-ray reflectors, the efficiency shown is lower than with the reflectors in the higher position. This discrepancy is probably due to the fact that the illumination measurements were made in positions symmetrically arranged over the floor. Since the X-ray reflectors have a considerable concentrating effect, the result may be accounted for by supposing that a greater percentage of the test stations happened to fall in points of high light concentration when the lamps were higher up than when they were nearer the floor. We may say, then, that the effect of lowering these lamps two feet three inches was practically *nil*.

Certain other tests were undertaken with incandescent lamps to show the distribution of illumination in other than the horizontal plane. One consisted in determining the illumination of a plane inclined at an angle at which a book would ordinarily be held by a person in the audience, facing the platform. This angle was chosen at fifty-two degrees, and the corresponding illumination values are given in their proper place in the tabulation.

A further test consisted in tilting the X-ray reflectors and lamps to such an angle as to give a maximum illumination on the platform in the front of a room and on the page of a book held by a person sitting in the audience, at the same time concealing the lamps from view. This was installation No. 14. The effect of this arrangement was very fine, the room being considered as an auditorium. To test the illumination values so obtained, and to

compare them with the illumination values obtained with the bare lamps, tip downward, and with the same lamps with reflectors, tip downward, the illumination was measured on a series of planes above the horizontal from vertical to vertical in all three cases. The results of such measurements show that acter would be much more evident. It is interesting to note also that with the bare lamps, tip downward, the illumination on a vertical plane is sixty per cent of the illumination on a horizontal plane, while with the mirrored reflectors, tip downward, this percentage is about thirty-five.

nary carbon lamps were used having an efficiency of 3.23 lumens per watt, we notice that the gross efficiency was 2.20 in the case of the Gem high-efficiency lamps and 2.35 in the case of the carbon lamps. This shows that, in spite of the higher efficiency of the lamps used, the illumination was more economically carried out

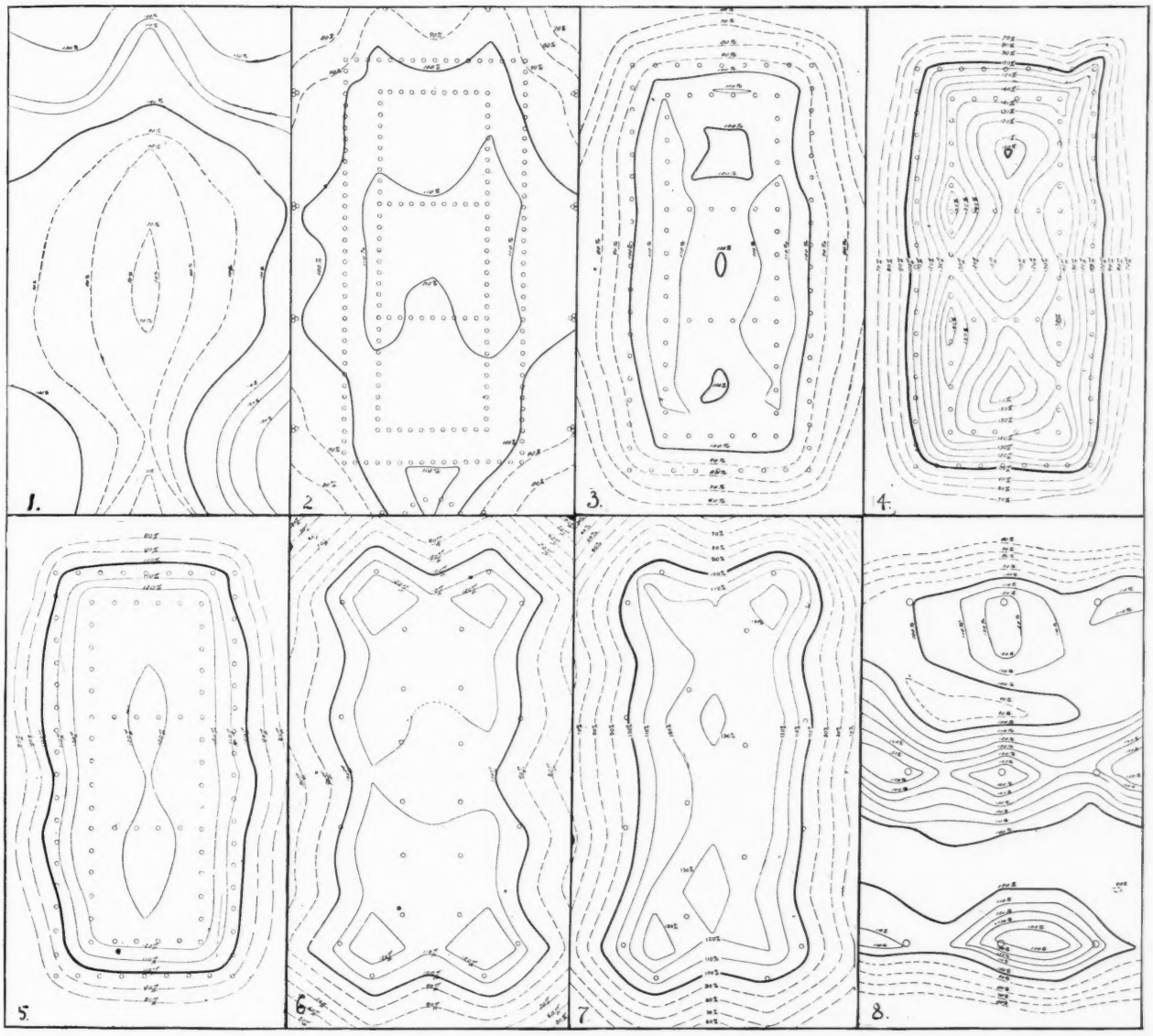


Fig. 2.—Diagrams Showing Lines of Uniform Illumination for Various Types of Installation. The Equilucial Lines Show Differences in Intensity of Ten Per Cent. Diagram 1 Shows the Effect of the Cove Lighting Alone; 2—Ceiling Lamps and Brackets, Frosted; 3—Concentrating Prismatic Reflectors, High Level; 4—Mirror Reflectors, High Level; 5—Distributing Reflectors, Low Plane; 6—Gem Lamps; 7—Tantalum Lamps; 8—Arc Lamps with Diffuser Shades.

tilting the reflectors gives a considerable increase in the amount of light received over the shoulders of persons in the audience, and that therefore this arrangement would be advantageous for auditorium purposes in general. If these results were reduced to a basis of equal watts expended in the lamps, the superiority of the tilted reflectors for illumination of this char-

Coming next to the consideration of the tests of other illuminants, we notice at once a large increase in lamp efficiencies. The increase in the gross efficiency of the installations is not in general correspondingly increased. Comparing, for example, test No. 16, in which Gem lamps were used, having an efficiency of 4.21 lumens per watt, with test No. 7, in which ordi-

with the 3.1-watts-per-candle carbon lamps than with the 2.5-watts-per-candle Gem lamps. This condition is connected directly with the higher net efficiency of the carbon-lamp installation, being seventy-three per cent, as against fifty-two per cent of the Gem. This is one of a number of striking examples which the test has brought out, showing how, by a

skilful arrangement of the lamps and selection of their equipment, the low-efficiency lamps may yield an illumination result more satisfactory than is done by more efficient lamps less skilfully installed. The results obtained by the lamp engineer in improving the lamp efficiency may be rendered entirely nugatory by the imperfections of the method of installing the same. It will be seen also that the gross efficiency of the enclosed arcs is in general less than that of the incandescent lamps with reflectors. Here again the net efficiency is low, and this is probably inherent, since the structure of the arc lamp does not render it practicable to use as efficient auxiliaries as can be used with the incandescent lamp. The tungsten lamp is far and away the most economical illuminant tested, both in lamp efficiency and in gross efficiency. Its gross efficiency is nearly twice that of the next best installation, in spite of the fact that the net efficiency of the tungsten-lamp installation is greatly exceeded in a number of instances.

As has been said previously, the data presented in this paper are capable, with careful analysis, of yielding many conclusions which lack of time has prevented us from bringing out.

The Occurrence of Copper and Lithium in Radium-Bearing Minerals.

Accepting Ramsay's recent statement that he has succeeded in producing lithium by subjecting copper in solution to the action of radium emanation, it might be expected that radioactive minerals bearing copper would also show the presence of lithium. To determine this point an investigation was made by H. N. McCoy with a number of samples of radioactive mineral. One of these was a pitchblende, from Gilpin county, Col. The sample contained considerable copper. The final filtrate, after the separation of the various analytical groups, contained only ammonium and alkaline salts. An examination of the latter spectroscopically gave a bright lithium line. Four other samples of uranium-radium minerals were then examined: two coming from Colorado, one from North Carolina and one from Bohemia. Three of these contained copper; the gummite from North Carolina showed no copper. However, all of the minerals showed the presence of lithium in small amount. The author points out that the discovery of lithium and copper in uranium-radium minerals does not necessarily indicate the change of copper into lithium, since the presence of lithium may have been fortuitous; but if Ramsay's observation be assumed to be accurate, it would be expected to find lithium in uranium-radium-copper minerals. The presence of lithium and the absence of copper in the gummite could be explained by the assumption that the change from copper into lithium had been completed. On the other hand, the presence of copper without a simultaneous presence of lithium would not constitute a valid argument against Ramsay's hypothesis, since the latter referred only to copper in solution and not in a solid state.—*Abstracted from Nature (London), November 28.*

The Olympic Club.

The ninth annual dinner of the Olympic Club, whose membership includes a number of electrical gentlemen, was held at Shanley's Roman Court, New York city, on Monday evening of this week. Fred E. Knapp is president of the club, and the dinner and entertainment committee consisted of James Kempster, George W. Millar and Cyrus O. Baker. The occasion was a most enjoyable one. After an excellent menu had been partaken of, a number of musical selections and recitations were rendered.

Among those present, in addition to the officers named above, were: J. B. Van Every, George H. Fearons, William Coverly, H. L. Shippy, George F. Porter, M. R. Cockey, A. L. Miller, E. A. Colby, James F. Wenman, Ernest Hopkinson, H. B. Jagoe, C. C. Champenois, R. H. Schleicher, C. W. Baker and Thomas J. Shanley.

The club owns beautiful grounds and a club house at Bay Shore, L. I., where many of the members spend their summers.

Nominations for Officers of the Illuminating Engineering Society.

The following nominations have been made by the nominating committee of the Illuminating Engineering Society for offices which are to be filled for the year 1908:

President—Dr. Louis Bell, Boston.

Vice-presidents—Arthur Williams, New York; C. E. Stephens, Pittsburg.

Directors—W. H. Gartley, M. K. Eyre, Bassett Jones, Jr.

General secretary—V. R. Lansingh.

Treasurer—Dr. A. H. Elliott.

The board of managers of the New England section of the society has made the following nominations for section officers: Chairman, J. S. Codman; secretary, R. C. Ware; managers, William H. Blood, Jr., T. H. Piser.

A SIMPLE PROOF THAT THE ARITHMETICAL MEAN IS THE BEST VALUE IN CASE OF DIRECTLY OBSERVED QUANTITIES.

BY H. SCHAPPER.

Let q_t stand for the true value of a quantity directly observable, and let

$$q = \frac{q_1 + q_2 + q_3 + \ldots + q_n}{n}$$

stand for the arithmetical mean.

When the measurements are carefully performed and repeated a large number of times it is then logical to assume that the probability of having some of the q's less than q_t is the same as that of having them larger than it. Also the probability of having some of the measurements exactly equal to q_t is great. Besides, the discrepancies among the q's themselves, as also the actual errors

$(q_t - q_1 = e_1, \ldots, q_t - q_n = e_n)$

will certainly be small in accurate and precise work.

We may write

$$q_1 = q_t + e_1, \ldots, q_n = q_t + e_n$$

where part of the e's will be + and part —. Adding, we get

$$q = q_t + \frac{e_1 + e_2 + e_3 + \ldots + e_n}{n} =$$

$$q_t + \frac{e}{n}$$

if we let e stand for the sum of all the errors.

$\frac{e}{n}$ becomes negligibly small as compared with q_t, if n becomes large, provided e does not increase when n increases. This requires the other condition that the values of the e's (the accidental errors) be individually very small. Moreover, the fact that the e's are not all of the same sign increases the chances of $\frac{e}{n}$ becoming very small when n becomes large, *i. e.*, for a large number of measurements.

Hence it follows that $q = q_t +$ a very small quantity, so that q is very close to the true value.

We can then say that the arithmetical mean is the best value of a series of direct observations, provided the measurements be precise. The larger the number of measurements the nearer q approaches the true value q_t.

Navy Department Supplies.

The Bureau of Supplies and Accounts, Navy Department, will open bids in Washington, D. C., on January 2, 1908, for the following electrical supplies: Miscellaneous electrical supplies for delivery at the Torpedo Station, Newport, R. I.; miscellaneous aluminum and platinum wire, for delivery at Pensacola, Fla.

ENERGY TRANSFORMATIONS FROM THE ELECTRICAL ENGINEERS' STANDPOINT.

BY H. M. HOBART.

(Concluded.)

The leading properties of steam are entered up in Tables V, VII and VIII. At the present time considerable difference of opinion exists among physicists with regard to the values of the specific heat of superheated steam at various temperatures and pressures. The values employed in the construction of Tables V, VII and VIII are in accord with those given by

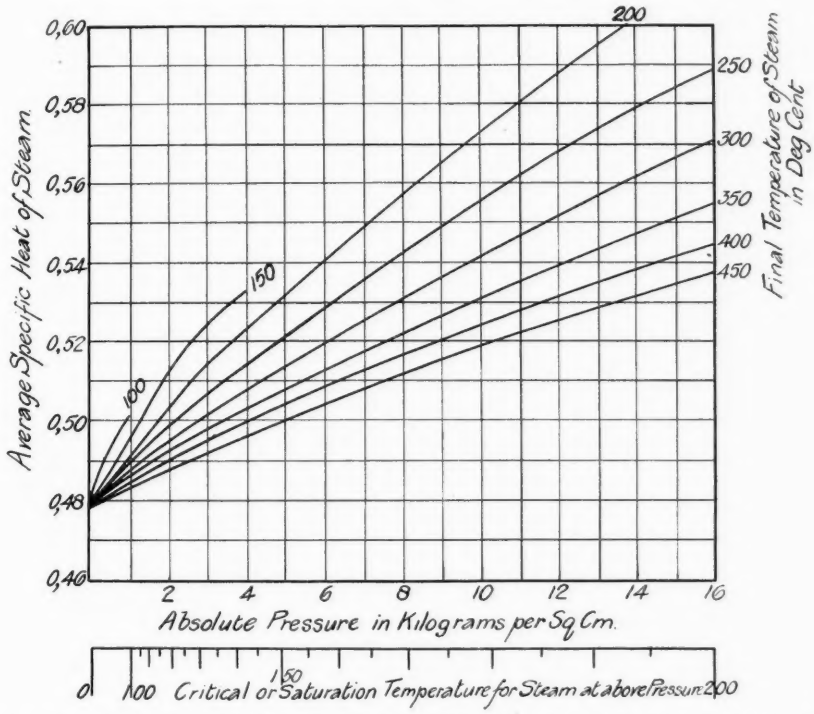


FIG. 3.—CURVES SHOWING THE AVERAGE SPECIFIC HEAT FOR STEAM SUPERHEATED FROM THE SATURATION TEMPERATURE TO VARIOUS HIGHER TEMPERATURES.

NOTE.—The above curves are plotted from results given by Mollier.

Mollier in his brochure entitled "Neue Tabellen und Diagramme für Wasserdampf."[1]

Mollier's values for the specific heat of steam are given in Table III. The values given in this table represent the average specific heat while the temperature of the steam is raised from the temperature of vaporization to various final temperatures. From these values the curves in Fig. 3 have been drawn.

The specific heat and specific gravity[2] of some common materials are given, together with the kilowatt-hour per ton per degree centimetre temperature rise, in Table IV.

[1] Published 1906 by Julius Springer, Berlin.

[2] The specific gravity of a body may be defined as the density or specific weight of the body in grammes per cubic centimetre, kilogrammes per cubic decimetre, or tons per cubic metre.

EXAMPLES OF THE AMOUNT OF ENERGY REPRESENTED BY ONE KILOWATT-HOUR.

1. One kilowatt-hour is sufficient to lift one ton through a height of 367 metres.

2. One kilowatt-hour is consumed at the trolley in propelling a ten-ton tramcar of good design on a good and level track for a distance of from one to two kilometres or thereabouts (according to the number of stops per mile), at a schedule speed of some twelve kilometres per hour.

3. One kilowatt-hour is absorbed in eighty-four hours by a twelve-candle-power lamp requiring one watt per candle-power. If the lamp is only in circuit for an average period of four hours per day, 17.4 kilowatt-hours will be absorbed by the lamp in the course of one year, provided that it survives for 1,660 hours in circuit with an average efficiency of one watt per candle-power and that its candle-power does not alter.

If the charge is six cents per kilowatt-hour, the cost of energy for this lamp will amount to $\frac{(1,660 \times 6)}{84} = 104$ cents for the year. Replacing the lamp once a year at a cost of forty-eight cents brings the total annual outlay per lamp to

$$\$1.04 + 0.48 = \$1.52.$$

To this must also be added an equitable proportion of the meter rental. On these assumptions the lamp thus costs a matter of $1.60 per year.

4. The latent heat of liquefaction of ice is ninety-three kilowatt-hours per ton; that is to say, to convert one ton of ice at zero degrees into one ton of water at zero degrees requires the application of ninety-three kilowatt-hours.

TABLE IV.

Material.	Specific Gravity (Tons per Cu. M.)	Specific Heat.	Kilowatt-Hours Required to Raise the Temperature of One Ton by One Degree.
Water	1.0	1.0	1.16
Ice	0.93	0.49	0.57
Coal	1.3	0.24	0.28
Wrought Iron..	7.7	0.11	0.13
Cast Iron.....	7.2	0.13	0.15
Copper	8.9	0.10	0.12
Lead	11.4	0.03	0.035
Zinc	6.9	0.09	0.11
Transformer Oil	0.9	0.75	0.97

5. The specific heat of ice is 0.49. Consequently to convert one ton of ice at — 8 degrees into water at zero degrees requires the application of 97.6 kilowatt-hours, this amount being accounted for as follows:

Four and six-tenths kilowatt-hours are required to raise the temperature of the ice to zero degrees, and ninety-three kilowatt-hours are required to liquefy the ice.

6. To convert one ton of ice at — 8 degrees into water at + 8 degrees requires the expenditure of 107 kilowatt-hours, this amount being accounted for as follows: as in Example 5, 97.6 kilowatt-hours are required to change the ice into water at zero degrees and a further 9.3

TABLE III.

TABLE OF THE AVERAGE SPECIFIC HEAT OF STEAM HEATED FROM THE TEMPERATURE OF VAPORIZATION AT VARIOUS FINAL TEMPERATURES.

Absolute Pressure in Kg. per Sq. Cm.		0.1	0.5	1	2	4	6	8	10	12	14	16
Temperature of Vaporization in Deg. Cent.		46	81	99	120	143	158	170	179	187	194	200
Final Temperature of Steam in Deg. Cent.	100	0.480	0.490	0.501	.....	.....	.....	.....	.....	.....	.....	.....
	150	0.479	0.488	0.495	0.513	0.533	.....	.....	.....	.....	.....	.....
	200	0.479	0.486	0.491	0.505	0.523	0.538	0.558	0.573	0.588	0.601	.....
	250	0.479	0.484	0.489	0.500	0.514	0.528	0.543	0.556	0.569	0.578	0.588
	300	0.479	0.483	0.487	0.496	0.508	0.519	0.531	0.541	0.551	0.562	0.569
	350	0.479	0.482	0.485	0.493	0.503	0.513	0.522	0.531	0.539	0.547	0.555
	400	0.478	0.482	0.484	0.491	0.500	0.508	0.517	0.523	0.531	0.538	0.545
	450	0.478	0.482	0.483	0.489	0.497	0.505	0.513	0.519	0.525	0.531	0.537

kilowatt-hours to raise the temperature of the water to eight degrees.

TABLE V.

TABLE OF THE ENERGY IN KILOWATT-HOURS REQUIRED TO CONVERT ONE TON OF WATER AT ZERO DEGREES CENTIGRADE INTO STEAM AT VARIOUS PRESSURES AND SUPERHEATS.

Absolute Pressure in Kg. per Sq. Cm.	Temperature of Vaporization in Deg. Cent.	Heat in Kilowatt-Hours per Ton. Component Parts. Water Heat.	Latent Heat.	50 Deg. Cent. Superheat.	100 Deg. Cent. Superheat.	150 Deg. Cent. Superheat.	Saturated Steam.	Total Steam Heat. Steam Superheated 50 Deg. Cent.	Steam Superheated 100 Deg. Cent.	Steam Superheated 150 Deg. Cent.
A	B	C	D	E	F	G	H	K	L	M
0.02	17	20	680	28	55	83	700	728	755	783
0.04	29	32	640	28	55	83	704	732	759	787
0.06	36	42	667	28	55	83	709	737	764	792
0.08	41	48	665	28	55	83	713	741	768	796
0.10	46	53	663	28	55	83	716	744	771	799
0.12	49	57	660	28	56	84	717	745	773	801
0.15	54	63	657	28	56	84	720	748	776	804
0.20	60	70	654	28	56	84	724	752	780	808
0.25	65	75	650	28	56	85	725	753	781	810
0.30	69	80	647	28	56	85	727	755	783	812
0.35	72	84	645	28	56	85	729	**757**	**785**	**814**
0.40	76	88	642	28	56	85	730	758	786	815
0.50	81	94	639	28	56	85	733	761	789	818
0.60	86	100	636	28	56	85	736	764	792	821
0.70	90	104	633	29	57	86	737	766	**794**	**823**
0.80	93	109	630	29	57	86	739	768	796	**825**
0.90	96	112	628	29	57	86	740	769	797	826
1.0	99	115	626	29	57	87	741	770	798	828
1.1	102	118	625	29	57	87	743	772	800	830
1.2	104	120	623	29	57	87	745	774	802	832
1.4	109	127	619	30	58	88	746	776	804	834
1.6	113	132	616	30	58	88	748	778	806	836
1.8	116	136	614	30	58	88	750	780	808	838
2.0	120	140	612	30	58	88	752	782	**810**	**840**
2.5	127	148	606	30	59	89	754	784	813	843
3.0	133	155	601	30	59	89	756	786	**815**	**845**
3.5	138	162	596	30	59	89	758	788	817	**847**
4.0	143	167	592	31	60	90	759	790	819	849
4.5	147	172	589	31	60	90	761	792	821	851
5.0	151	177	587	31	61	90	764	795	825	854
5.5	155	182	584	31	61	91	766	797	827	857
6.0	158	186	581	31	61	91	767	798	828	858
6.5	161	189	578	32	62	92	767	799	829	859
7.0	164	193	575	32	62	92	768	800	830	860
7.5	167	196	573	32	62	92	769	801	831	861
8.0	170	199	571	32	62	92	770	802	832	862
8.5	172	202	569	32	62	92	771	803	833	863
9.0	174	205	566	33	63	93	771	804	834	864
9.5	177	208	564	33	63	93	772	805	835	865
10.0	179	211	562	33	63	93	773	806	836	866
11.0	183	216	559	33	63	93	775	808	838	868
12.0	187	220	556	33	64	94	776	809	840	870
13.0	191	225	552	33	65	95	777	810	842	872
14.0	194	229	549	33	65	96	778	811	843	874
15.0	197	233	545	34	66	97	778	812	844	875
16.0	200	237	542	34	66	97	779	813	845	876
18.0	206	244	536	35	67	98	780	815	847	878
20.0	211	250	531	35	68	99	781	816	849	880

7. The average specific heat of transformer oil is 0.75, of copper 0.1, of iron laminations 200 kilogrammes, the cast-iron case 150 kilogrammes, and the oil 180 kilogrammes. The internal loss amounts to one kilowatt and it is required to find the time required to cause a rise of temperature of forty degrees, assuming that the heat is exclusively employed in causing a rise of temperature and that none is radiated from the external surface of the frame.

The oil requires $0.75 \times 1.16 \times 0.18 \times 40 = 6.3$ kilowatt-hours. Similarly the copper requires 0.46 kilowatt-hours, the laminations one kilowatt-hour, and the frame 0.75 kilowatt-hour. The total heat required is 8.5 kilowatt-hours, so that if the losses in the transformer are one kilowatt, the time would be 8.5 hours, under the conditions set forth.

ENERGY TRANSFORMATIONS.

Electrical energy, or, briefly, electricity, can be transformed into work energy—or work with an efficiency as high as ninety-five per cent in large motors. Work may be transformed into electricity with equally high efficiency. The remaining five per cent or more is converted into heat energy or, briefly, into heat. Electricity and work may both be converted into heat with an efficiency of 100 per cent. Thus if an electric current is sent through a resistance, the electrical energy is entirely converted into heat in the resistance. If work is performed in stirring water, as in Joule's experiment, the work energy may be entirely transformed into heat energy. The "generation" of electrical energy in generating stations is strictly the transformation of energy from heat to electricity.

When, however, we wish to convert heat into electricity, or into work, high efficiencies are not attainable. There are no known means of transforming heat directly into electricity on a large commercial scale. Heat may, with a low efficiency, be transformed into work in a steam engine or a gas engine, and the work may, at high efficiency, be transformed into electrical energy. The large portion which, in the first step, is not transformed into work, remains heat; the small part which, in the second step, is not transformed into electricity, is converted into

TABLE VI.

HEAT ENERGY IN KW. HR. RENDERED AVAILABLE FOR CONVERSION INTO MECHANICAL WORK BY THE EXPANSION OF ONE TON OF STEAM.

Exhaust Pressure in Kg. per Sq. Cm.	Admission Pressure in Kg. per Sq. Cm. 16			14				12				10				8				7				Heat energy in kw. hr. per ton) available for conversion into work
	Admission Temperature in Degrees Centigrade																							
	200	250	300	194	200	250	300	187	200	250	300	179	200	250	300	170	200	250	300	158	200	250	300	
0.05	228	243	261	225	226	241	256	219	223	236	250	211	217	230	242	202	209	222	234	191	200	212	226	
0.1	210	224	240	205	208	220	238	199	204	215	238	190	197	208	222	180	188	199	214	170	179	190	203	
0.2	188	200	214	183	185	197	210	176	179	190	204	168	174	182	197	158	165	174	187	146	154	163	177	
0.4	162	175	188	158	154	172	183	151	153	165	176	144	148	157	169	133	139	148	160	122	129	137	150	
0.6	148	160	173	143	144	155	168	137	139	150	161	127	132	142	153	118	123	132	143	105	112	121	132	
0.8	138	147	160	132	132	144	154	125	128	138	147	117	120	130	140	107	111	120	130	95	100	108	120	
1.0	128	139	152	123	123	134	146	116	119	128	128	108	112	120	130	97	102	110	119	85	90	99	109	
1.5	114	122	133	106	108	118	128	100	102	111	120	91	94	102	111	80	83	92	101	67	72	79	90	

NOTE:—The values for steam initially saturated are set in heavier type.

(or lost as) heat. Of the heat absorbed by a large steam engine or steam turbine, its less reliability at the present stage of its development.

TABLE VII.

TABLE OF SPECIFIC VOLUME AND SPECIFIC WEIGHT OF SATURATED AND SUPERHEATED STEAM.

Absolute Pressure in Kg. per Sq. Cm.	Temperature of Vaporization in Deg. Cent.	Specific Volume in Cu. M. per Kg.				Specific Weight in Kg. per Cu. M.			
		Saturated Steam.	Steam Superheated 50 Deg. Cent.	Steam Superheated 100 Deg. Cent.	Steam Superheated 150 Deg. Cent.	Saturated Steam.	Steam Superheated 50 Deg. Cent.	Steam Superheated 100 Deg. Cent.	Steam Superheated 150 Deg. Cent.
A	B	N	O	P	Q	R	S	T	U
0.02	17	68.0	81.0	93.0	105.0	0.015	0.012	0.011	0.010
0.04	29	35.0	42.0	48.0	54.0	0.028	0.024	0.021	0.019
0.06	36	24.0	28.0	32.0	36.0	0.042	0.036	0.031	0.028
0.08	41	18.0	21.0	24.0	27.0	0.055	0.047	0.041	0.037
0.10	46	15.0	17.0	20.0	22.0	0.066	0.058	0.051	0.046
0.12	49	12.0	15.0	17.0	19.0	0.081	0.069	0.061	0.054
0.15	54	10.0	12.0	13.0	15.0	0.100	0.085	0.075	0.067
0.20	60	8.0	9.0	10.0	11.0	0.130	0.112	0.099	0.089
0.25	65	6.4	7.3	8.3	9.2	0.16	0.14	0.12	0.11
0.30	69	5.3	6.1	6.9	7.7	0.19	0.16	0.14	0.13
0.35	72	4.6	5.3	6.0	6.6	0.22	0.19	0.17	0.15
0.40	76	4.0	4.6	5.3	5.9	0.25	0.22	0.19	0.17
0.50	81	3.3	3.8	4.3	4.7	0.31	0.26	0.24	0.21
0.60	86	2.8	3.2	3.6	4.0	0.36	0.31	0.28	0.25
0.70	90	2.4	2.8	3.1	3.4	0.42	0.36	0.32	0.29
0.80	93	2.1	2.4	2.7	3.0	0.48	0.41	0.37	0.33
0.90	96	1.9	2.2	2.4	2.7	0.53	0.46	0.41	0.37
1.0	99	1.7	2.0	2.2	2.4	0.59	0.51	0.45	0.41
1.1	102	1.6	1.8	2.0	2.2	0.64	0.56	0.50	0.45
1.2	104	1.4	1.7	1.9	2.1	0.70	0.60	0.54	0.49
1.4	109	1.2	1.4	1.6	1.8	0.80	0.70	0.63	0.57
1.6	113	1.1	1.3	1.4	1.6	0.92	0.79	0.71	0.64
1.8	116	1.0	1.1	1.3	1.4	1.02	0.89	0.80	0.71
2.0	120	0.89	1.02	1.14	1.26	1.1	1.0	0.9	0.8
2.5	127	0.72	0.83	0.93	1.02	1.4	1.2	1.1	1.0
3.0	133	0.61	0.70	0.78	0.86	1.6	1.4	1.3	1.2
3.5	138	0.52	0.60	0.68	0.74	1.9	1.7	1.5	1.4
4.0	143	0.46	0.53	0.59	0.67	2.2	1.9	1.7	1.5
4.5	147	0.43	0.47	0.53	0.58	2.4	2.1	1.9	1.7
5.0	151	0.37	0.43	0.47	0.52	2.7	2.3	2.1	1.9
5.5	155	0.34	0.39	0.44	0.48	2.9	2.5	2.3	2.1
6.0	158	0.32	0.36	0.40	0.44	3.2	2.8	2.5	2.3
6.5	161	0.29	0.34	0.37	0.41	3.4	3.0	2.7	2.5
7.0	164	0.27	0.31	0.35	0.38	3.7	3.2	2.9	2.6
7.5	167	0.26	0.29	0.32	0.35	3.9	3.4	3.1	2.8
8.0	170	0.24	0.28	0.30	0.33	4.1	3.5	3.3	3.0
8.5	172	0.23	0.26	0.29	0.31	4.4	3.8	3.5	3.2
9.0	174	0.22	0.24	0.27	0.30	4.6	4.1	3.7	3.4
2.5	177	0.21	0.23	0.26	0.28	4.9	4.3	3.9	3.6
10.0	179	0.20	0.22	0.24	0.27	5.1	4.6	4.1	3.8
11.0	183	0.18	0.20	0.22	0.24	5.6	5.0	4.5	4.1
12.0	187	0.16	0.18	0.20	0.22	6.1	5.4	4.9	4.5
13.0	191	0.15	0.17	0.19	0.21	6.5	5.9	5.3	4.8
14.0	194	0.14	0.16	0.18	0.19	7.0	6.4	5.7	5.2
15.0	197	0.13	0.15	0.16	0.18	7.5	6.8	6.1	5.6
16.0	200	0.12	0.14	0.15	0.17	7.9	7.3	6.6	6.0
18.0	206	0.11	0.12	0.14	0.15	8.9	8.2	7.4	6.8
20.0	211	0.10	0.11	0.13	0.14	9.6	8.9	8.1	7.5

during the passage of the steam, only some sixty per cent can, in the present state of the art, ultimately be converted into electricity.

When we trace the process back to the calorific contents of the fuel, it may be stated that only about 7.5 per cent can be converted into electricity. With gas engines, some twenty-five per cent of the calorific value of the fuel may be transformed into electricity in the circuits supplied from the dynamo driven by the engine. The greater efficiency of the gas engine is, however, in large units, offset by the greater cost, greater depreciation and greater space required, as also in many cases, by the disadvantage associated with its less uniform turning moment and

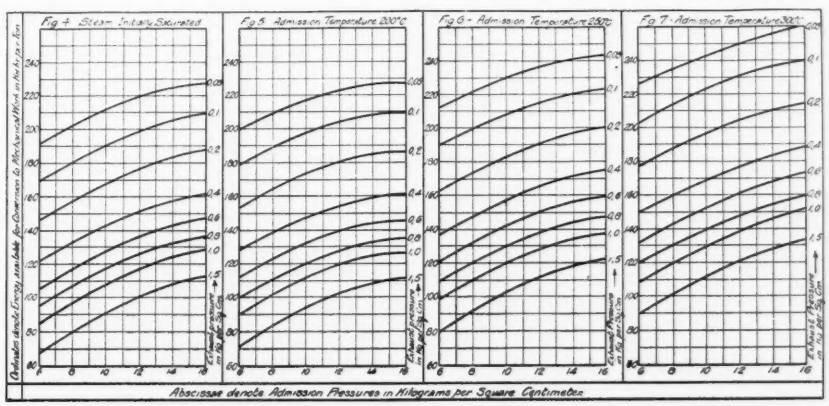


Fig 4. Steam Initially Saturated
Fig 5. Admission Temperature 200°C
Fig 6. Admission Temperature 250°C
Fig 7. Admission Temperature 300°C
Ordinates denote Energy available for Conversion to Mechanical Work in Kilogram-Metres per Kilogram of Steam
Abscissae denote Admission Pressures in Kilograms per Square Centimetre
Exhaust Pressure in Kg. per Sq. Cm.

FIGS. 4–7.—HEAT ENERGY (MEASURED IN KILOWATT-HOURS) RENDERED AVAILABLE FOR CONVERSION INTO MECHANICAL WORK BY THE EXPANSION OF ONE TON OF STEAM.

Let us therefore direct our attention to the steam engine or steam turbine, which, as already stated, permits, in large sets, of converting into electrical energy some sixty per cent of the energy abstracted from the steam in its passage through the engine.

In accordance with this definition of the efficiency of an engine, the heat rejected to the condenser is not regarded as a loss.

It may be, for instance, and often is, employed in heating processes. Waste-heat engines have also been devised for employing the lower temperature ranges. Whether or not it be expedient further to employ the heat energy rejected to the condenser, it is nevertheless heat energy. Subtracting this energy from that contained in the steam at admission, we have as the remainder the energy which has undergone transformations in the steam engine or turbine. A large portion of this has been converted from heat energy into useful work energy, and the remainder is ultimately wasted in heating the engine and the surroundings.

The ratio of the energy delivered from the engine as work, to the energy which has been absorbed in the engine, is designated the "thermodynamic" efficiency. In Table VI are set out the amounts of "convertible" energy per ton of steam when working between various admission pressures and temperatures and various exhaust pressures. With an engine of sixty per cent "thermodynamic" efficiency the work energy obtained per ton of steam is equal to 0.60 of the "convertible" energy set forth in the table.

The values obtained in the table are determined on the assumption of expansion without loss or gain of energy by the steam. Its temperature during this process of so-called "adiabatic" expansion decreases in accordance with definite thermodynamic laws into which it is not

proposed to enter. Accompanying the decrease in temperature there is, for certain ranges, a condensation of a portion of the steam. The corresponding "wetness factors" are set forth in Table IX.

TABLE VIII.

TABLE OF THE ENERGY IN KILOWATT-HOURS REQUIRED TO CONVERT ONE TON OF WATER AT ZERO DEGREES CENTIGRADE INTO STEAM AT VARIOUS TEMPERATURES AND PRESSURES.

Absolute Pressure, in Kg. per Sq. Cm.	Temperature of Vaporization in Deg. Cent.	Steam Heat of Saturated Steam in Kw.-Hr. per Ton.	Steam Heat (in Kilowatt-Hours per Ton) of Steam Superheated to Following Final Temperatures in Deg. Cent.							
			100 Deg.	150 Deg.	200 Deg.	250 Deg.	300 Deg.	350 Deg.	400 Deg.	450 Deg.
A	B	C	D	E	F	G	H	K	L	M
0.02	17	700	747	775	803	831	859	885	913	940
0.04	29	704	747	775	803	831	859	885	913	940
0.06	36	709	747	775	803	831	859	885	913	940
0.08	41	713	747	775	803	831	859	885	913	940
0.10	46	716	746	774	802	830	858	884	912	940
0.12	49	717	746	774	802	830	858	884	912	940
0.15	54	720	746	774	802	830	858	884	912	940
0.20	60	724	746	773	802	830	858	884	912	940
0.25	65	725	745	773	801	824	858	884	912	940
0.30	69	727	745	773	801	824	858	884	912	940
0.35	72	729	745	773	801	824	858	884	912	940
0.40	76	730	745	773	801	824	858	884	912	940
0.50	81	733	744	772	800	828	857	883	911	939
0.60	86	736	744	772	800	828	857	883	911	939
0.70	90	737	744	772	800	828	856	883	911	939
0.80	93	739	744	771	800	827	856	883	911	939
0.90	96	740	744	771	800	827	856	883	911	939
1.0	99	741	742	770	799	826	855	882	911	938
1.1	102	743		770	799	826	855	882	911	938
1.2	104	745		770	799	826	855	882	911	938
1.4	109	746		770	799	826	855	882	911	938
1.6	113	748		770	799	826	855	882	911	938
1.8	116	750		770	799	826	855	882	911	938
2.0	120	752		769	798	826	854	882	911	938
2.5	127	754		768	797	826	854	881	911	938
3.0	133	756		767	796	825	853	881	911	938
3.5	138	758		766	795	825	853	880	911	938
4.0	143	759		764	794	824	852	879	910	938
4.5	147	761			794	824	852	879	910	938
5.0	151	764			794	824	852	879	910	938
5.5	155	766			794	824	852	879	910	938
6.0	158	767			793	823	852	879	910	938
6.5	161	767			792	822	852	879	909	938
7.0	164	768			791	822	851	879	909	938
7.5	167	769			790	821	851	879	909	938
8.0	170	770	Wet steam.	Wet steam.	789	820	850	879	908	937
8.5	172	771			789	820	850	879	908	937
9.0	174	771			798	820	850	879	908	937
9.5	177	772			798	820	850	879	908	937
10.0	179	773			787	819	849	878	908	936
11.0	183	775			786	819	849	878	908	936
12.0	187	776			785	818	848	878	907	936
13.0	191	777			784	817	848	878	907	936
14.0	194	778			782	816	847	877	907	936
15.0	197	778			781	815	846	877	906	936
16.0	200	779			779	813	845	876	905	935
18.0	206	780			779	812	844	876	905	935
20.0	211	781			779	811	843	815	905	935

It is the writer's experience that by means of the system and tables above set forth the general problems associated with electricity supply and distribution may be solved more effectively than is otherwise possible. Calculations which, by older methods and mixed units, have been tedious and involved, may be readily carried out and the significance of each stage of the calculations becomes much more evident.

Since, however, the designation "kilowatt-hour" is illogical and obscure, it is highly desirable that it be replaced by some suitable name. It has been suggested (editorial in the [London] *Times Engineering Supplement* for August 7, 1907), that this quantity might be termed a "kelvin" or a "kapp." The latter term would be ideal from the standpoint of brevity. The energy in one ton of good coal is some eight to nine "kilokapps.' At a price of $3.50 per ton, this works out at some forty-four cents to thirty-nine cents per "kilokapp." If the annual over-all efficiency of an electricity supply station is, in some particular case, ten per cent, then the fuel cost per "kapp" delivered at the outgoing cables is some forty cents. The remaining running costs would raise this to a total of some sixty cents for the total operating costs. If, with fifty-per-cent load-factor, 200 million "kapps" are delivered annually from the generating station, the capital cost for a station designed on modern lines works out at some $15,000 per million "kapps" per annum. On the basis of seventeen per cent for interest and depreciation, this constitutes an annual charge of twenty-six cents, thus bringing the total cost per unit up to about eighty-six cents per "kapp" delivered from the generating station. By similar calculations for the cost of cables, substations and low-tension network and for the cost of the energy wasted in these components of the system, the cost delivered to the customer may be estimated.

If the proposal to substitute the short word "kapp" for the kilowatt-hour does not find acceptance, the above ready means of following through such calculations are not invalidated and it is merely required to substitute in the text the usual term kilowatt-hour.

TABLE IX.

WETNESS FACTORS AT EXHAUST FOR STEAM EXPANDED ADIABATICALLY FROM VARIOUS INITIAL TEMPERATURES AND PRESSURES.

Exhaust Pressure in Kg. per Sq. Cm.	Admission Pressure in Kg. per Sq. Cm.																							
	16			14				12				10				8				6				
	Admission Temperature in Degrees Centigrade.																							
	200	250	300	174	200	250	300	187	200	250	300	179	200	250	300	170	200	250	300	158	200	250	300	
0.05	0.24	0.21	0.19	0.23	0.23	0.21	0.18	0.23	0.22	0.20	0.17	0.22	0.20	0.18	0.16	0.22	0.20	0.18	0.15	0.20	0.18	0.15	0.13	Wetness Factors.
0.1	0.23	0.20	0.17	0.22	0.22	0.19	0.16	0.22	0.21	0.18	0.15	0.21	0.19	0.16	0.14	0.21	0.18	0.14	0.13	0.18	0.16	0.13	0.10	
0.2	0.21	0.17	0.14	0.19	0.19	0.16	0.13	0.19	0.18	0.15	0.12	0.18	0.17	0.14	0.11	0.17	0.15	0.12	0.09	0.16	0.13	0.10	0.07	
0.4	0.18	0.14	0.11	0.16	0.16	0.13	0.10	0.16	0.15	0.12	0.09	0.15	0.14	0.10	0.08	0.14	0.12	0.09	0.06	0.12	0.10	0.07	0.04	
0.6	0.17	0.13	0.09	0.15	0.15	0.11	0.38	0.15	0.13	0.10	0.07	0.14	0.12	0.09	0.06	0.13	0.11	0.08	0.04	0.11	0.09	0.05	0.01	
0.8	0.16	0.12	0.08	0.13	0.13	0.10	0.07	0.14	0.12	0.09	0.06	0.13	0.11	0.08	0.04	0.11	0.09	0.06	0.03	0.10	0.07	0.04	...	
1.0	0.14	0.10	0.07	0.12	0.12	0.09	0.06	0.12	0.11	0.08	0.04	0.12	0.10	0.07	0.03	0.10	0.08	0.04	0.05	0.09	0.06	0.02	...	
1.5	0.11	0.08	0.05	0.11	0.11	0.07	0.04	0.10	0.09	0.06	0.03	0.09	0.08	0.04	0.01	0.08	0.06	0.03	...	0.07	0.04	...	...	

NOTE:—The values for steam initially saturated are set in heavier type.

The data in Table VI are plotted in the curves of Figs. 4-7.

Illuminating Engineering Society.

The New York section of the Illuminating Engineering Society held a meeting in the Engineering Societies Building, Friday, December 12, to hear and discuss a paper by Bassett Jones, Jr., entitled "The Relation of Architectural Principles to Illuminating Engineering Practice." In this paper Mr. Jones makes an earnest appeal for the æsthetic treatment of illuminating problems for structures making an appeal to the sense of beauty. To do this, he believes, requires a more or less developed sympathy with the æsthetic qualities of the design. The purpose of his paper was to show that the illuminating engineer who considers only the scientifically practical side of his problems is necessarily doomed to ultimate failure, for he will not be able to obtain the recognition that the importance of his work deserves.

To approach this study properly it is necessary to have an understanding of the nature of "æsthetic." When we view a magnificent and artistic composition for the first time it produces in us a very delicate poise between the two extremes of novelty and recognition. In many ways it is the same as more familiar objects and yet there are characteristics about it that are quite new. The attention is thus aroused to a high pitch of nervous excitement, due to the novelty, and must find its release in a discharge one way or the other. If the balance is in favor of interest, the result will be a pleasurable emotion. For an appreciation of the beautiful sympathy is primarily necessary. The object must embody an expression of the observer's ideas of appropriateness and fitness. The culture of the imagination is also of great importance for the appreciation of the beautiful. The artist seeks to give material reality to his ideas through the means at his command and the public must appeal to memory and imagination for its development and meaning. The necessity for finding a similarity, an old sensation of pleasure to match, through which novel developments may be adapted to our present stock of æsthetic memories, has given rise to the schools and orders. There is a fundamental similarity in all the features of each period which arouses a sense of rest. But the readiness with which the harmony of the design will be appreciated is much a matter of previous training.

Proportion may also be deduced through the interest which the object holds for us. The meaning of an object which has no evident order in its arrangement defies detection and repels rather than attracts the imagining activities. The organic analogue of the feeling of proportion is found in a concordant and orderly change in the muscular reflexes which the stimulus arouses. There is no sense of disruptive and violent alteration. The pleasure which an easy curve excites is largely due to the sense of ease with which the eye-muscles follow its contour. The feeling of the beautiful, however, is never merely the feeling of the agreeable. For beauty depends on three things: pleasure attaches to form and not material of sensation; the object must be recognized as implying relations not immediately present; and there must be some concordant series or composite of agreeable objects.

The author then discussed the principles of architecture, showing how these necessarily must govern the type of illumination selected for any particular place. Architecture, primarily, has for its purpose the provision of structures designed to furnish protection from the vicissitudes of climate. The requirement of familiarity then demands of the architect that his structure shall so appeal to memory as to make evident its secondary purpose. The requirement that the several parts of the object or building shall arouse concordant sensations demands that the relations between the several parts of the object shall be apparent. The technical name of this character is "proportion." Its importance can not be overestimated. All throughout ancient architecture there was an evident attempt to carry it to its logical extreme. No artificial object was considered too insignificant to express some definite proportional relation. This principle is illustrated by a square and rectangle. The proportions of the former are evident at a glance, so that no interest is aroused; the latter, however, has sides longer than the ends. This at once attracts the eye. The attention is challenged, and curiosity is aroused, which endeavors to find the proportional relation between the two parts of the rectangle.

The genesis of ornament has its root in the very human characteristics of conceit and pride, but those who can grasp the true worth of proportion require no ornament to set it off. Human effort and skill, however, are so far limited that the deed is never the perfection of the thought, and this lack of unambiguous expression of the function of each part of our utilitarian construction compels the use of ornament as a means of emphasis and a sign of the use to which each part is put; for, parts differing in function must differ in appearance. Hence it is evident that in the proper or improper use of ornament is the success or failure of the whole design.

Turning then to the relations between the architect and the illuminating engineer, the author pointed out that, as had been shown, the principles of architecture are no mere whim on the part of the designer. They are as deeply rooted in a basis of fact as are the principles of natural philosophy, and the conceptions of good architecture are subject to the same order of constraint that limits the postulates of science. These facts seem to have been overlooked by the authors of a number of recent contributions to literature on illumination which have shown a disposition to criticize the limitations which architects place upon their work. They do not seem to realize that the beauty and effectiveness of good architectural construction depend upon a strict adherence to the principles outlined above, and that the feeling of the design, dependent as it must be upon historical precedent, is bound by centuries of usage to certain effects of color and light which have become established because of their appeal to the sentiments aroused by pleasurable visual perception. The business of the illuminating engineeer is to modernize old methods of illumination without destroying them. If we are to discard tradition altogether, then we may as well abandon the architecture of the past and ignore its influence.

The "feeling" of the design must be carried out consistently, even to the last detail of the fixtures, and it is the duty of the architect to see that this is done. His conception of the whole arrangement must include the lighting, for, as he sees it "in his mind's eye," so it must be seen objectively. The light that must be provided, its tone, its intensity, its quality, are features of his mental conception, and it is this ideal illumination that the engineer must seek to approximate. He can only hope to do this when he is able to see the design as the architect sees it, and not through the eyes of the illuminating specialist. The illuminating engineer must use the laws of distribution, not as a method of determining what the distribution shall be, but as a means of adapting his lamps to the distribution required. It is not a question of foot-candles; it is a question of how much light is needed. And it is more often a question of quality than of quantity. It seems then that a very important, if not essential, feature of the engineer's preparation is a study of the history of illumination and its relation to architectural design. He must

make himself intimately acquainted with the means and methods of earlier work, which was good work where any attempts were made to obtain adequate and suitable lighting. It is not true that good lighting has not been achieved earlier by empirical methods. We to-day are simply in a position to do more efficiently what the masters have done in spite of their manifest limitations. This branch of illuminating engineering is unquestionably an art, and only a science in so far as an art is scientific in its method. The question of the proper location and arrangement of fixtures then resolves itself into the question of the way in which the design is to be seen. The proportions of the structure, its constructive lines and the points where they originate and end—these are to be brought out in relative prominence, and to do this properly the individual responsible for the lighting must be able to discern and select these features and modify his illumination accordingly.

The author then presented several examples of the use of historic precedent in illumination and showed drawings of fixtures thought suitable for various purposes. The archæologist has presented us with an almost infinite variety of Roman lamps and stands of exquisite design. Some of these were described, as well as adaptations of them to modern methods. Only by such historical study did he think that we can learn the nature of the ideal which the great masters of architecture sought to embody in their work, and only as we succeed in making this ideal our own can we hope to express in our efforts the truth of architectural beauty.

The author closed with a word or two regarding the physiological effects of artificial illumination. He believes that no architectural design, conceived in the right spirit and properly executed, can demand any suitable artificial illumination that is injurious in the optical sense. The reasons for this lie deeper than the physiology of the eye can lead us, and have to do also with visual perception and psychology. Artistic illumination is, *ipso facto,* good illumination. No illumination can be artistic that is not conceived as a feature of a truly artistic design.

The discussion of the paper was opened by L. B. Marks, who, while expressing his general agreement with the author's theme, took issue with him on a number of points. He said that certain buildings are purely utilitarian and in no sense æsthetic. Hence there is no necessity to consider the æsthetic feeling when laying out their illumination. Since a fixture is intended to supply light, it should be designed with this idea in view, and no æsthetic feeling should be allowed to make it an inefficient fixture. Where illumination is to be useful, the æsthetic consideration takes second place. When it is desired to maintain old traditions, the æsthetic side should be considered, but these ideas should be changed when necessary and discarded when not good. Mr. Marks took issue with the author's statement that illumination is not a question of foot-candles; it is, although the quality of lighting must also be considered. Illuminating science is to-day producing definite methods of treatment, while the old empirical methods were only occasionally successful. It is thought that one of the difficulties at the present time is due to the neglect on the part of the architect to consider the artificial illumination of his buildings until its design is practically completed. Mr. Marks criticized certain of the fixtures shown by Mr. Jones, pointing out how they might be improved, and concluded by saying that artistic illumination is not necessarily good physiologically.

S. W. Jones discussed the paper from the viewpoint of the architect, expressing agreement with the author's opinions. He said there are two classes of buildings to-day: the modern office building or skyscraper, and buildings of historic design. For the first class, efficient lighting is a prime consideration; for the second the architect is best fitted to design the illumination. He called attention to one figure in the paper, saying that sufficient illumination would have been secured by half the number of lamps on each chandelier, but the design of the latter had to be massive in order to be in harmony with the room, which made it necessary to place an excessive number of lamps upon it. Mr. Jones concluded by saying that the engineer, as usually trained, is not fitted to design the illumination of a historically designed building; it is for the architect to decide what illumination is to be used. The illuminating engineer blunders when he tries to apply commercial methods to other buildings.

L. R. Hopton discussed the difficulties of fixture design from a fixture man's standpoint and contended that fixture designers have used good judgment and good methods in their work, and that the blunders of a few should not be visited upon the entire fraternity.

W. S. Kellogg said that it is always necessary to bear in mind the artistic principle of beauty. Fixtures must be in harmony with the building and the architect must be the judge of what is desired. He thought that it is the question of the quantity, rather than the quality, of the lighting which controls the illuminating engineer, while the reverse should be the case. Mr. Kellogg said that much of the difficulty in the present situation has been due to the increasing intensity of the units of illumination. These, he thinks, are too large; that even the ordinary lamp would be better if it had an intensity of eight rather than sixteen candles.

V. R. Lansingh expressed his agreement in general with the ideas put forth in the paper; for much work the illuminating engineer should have an artistic feeling; yet in nine out of ten cases the illumination should be purely useful. In these cases the artistic considerations do not control; in the others they come first. But even here engineering principles should be applied in order to reduce the expense of the lighting. Smaller lamps are, in general, good, but the objection to them is the increased cost of installation and operation.

G. H. Stickney also expressed appreciation of the argument of the paper, but thought it was somewhat idealistic, with a tendency to go to extremes. He discussed briefly the various kinds of illuminating problems that come up, showing how they necessarily influence the method of treatment.

E. L. Elliott said that the difficulty to-day is due to the fact that the architect and the illuminating engineer are working in fields which overlap. There is a neutral ground where they must necessarily work together for the best results. Due to this, each should endeavor to understand the position of the other, to be able to see the problem as the other sees it. When this has been brought about, then each will be able to go over into the field belonging strictly to the other and appreciate the work which the latter is doing. He rather disagreed with the author in holding that we should follow the ideals of the ancients. The old buildings were simple in construction and for simple purposes; the office building to-day is infinitely more complex. It is designed for purely utilitarian purposes and hence the methods of illumination employed should not be restricted by old practice. Mr. Elliott said that many of our modern buildings for libraries and schools are designed from ancient models where the lighting was unimportant, and yet these are the very buildings which to-day need the most il-

lumination. He thought that in many cases the æsthetic principles must be subsidiary to the principles of illumination; that everything must have some purpose; and since a fixture is placed in a room for supplying light, its purpose must be evident. The fixture is not itself a part of the room and need not be massive, although the furnishings of the room are. Old fixtures were intended to support flaming lamps, and to copy them to-day is not only to neglect modern advance, but actually to present an untruth. We should not continue to imitate old designs without creating.

Due to the lateness of the hour, Mr. Jones closed the discussion briefly. He called attention, however, to the fact that his paper was, as stated in it, limited to a consideration of structures making an appeal to the sense of beauty. He said that the reasons for following old traditions lie deep. Beauty actually has an effect on the morals of the community, and only by increasing the æsthetic feeling of the people is it possible to raise them morally. He said, in reply to Mr. Elliott, that a lighting fixture is part of a room, since it is there in the daytime as well as at night, and hence it must be in harmony with the other furnishings. Others who took part in the discussion were A. J. Marshall and J. C. Codman.

The meeting was then adjourned.

Municipal Lighting for Montreal.

Estimates upon the cost of construction and operation of a municipal lighting plant for Montreal, Quebec, were ordered last July and have been prepared by Messrs. Ross & Holgate, electrical engineers. The report says that the city would need to rebuild the present incinerator plant at a cost of $102,960. To this would be added the cost of an electrical plant, at $182,110, making a total capital cost of $285,070. The operating cost would be $65,143, from which would be deducted the expense of operating the present incinerator, amounting to $13,324, leaving a balance of $51,819. The city would have at its disposal 330 horse-power during twelve hours of the day, which, valued at $30 per horse-power, would amount to $9,900. Deducting this from the foregoing, a balance of $41,919 would remain as the cost of lighting. This distributed over 733 arc lights would give a cost of $57.18 per light. The city now pays $60 a light. The engineers conclude that the garbage of the city has more than sufficient heat value to generate all the power required for lighting purposes.

THE CHANGE IN THE RESISTANCE OF METALS AT VERY LOW TEMPERATURES AND THE INFLUENCE EXERTED ON IT BY SMALL AMOUNTS OF ADMIXTURES.[1]

BY PROFESSOR H. KAMERLINGH ONNES AND J. CLAY.

In a previous communication the authors called attention to the changes of resistance with temperature which platinum wires show at the low temperatures reached with liquid hydrogen. Such differences were still more pronounced for different gold wires which we investigated. With this metal we investigated the influence of small amounts of admixture, as we thought that the gold resistance thermometer would be preferable to the platinum resistance thermometer.

As to the change of the specific resistance for the pure metals reduced to the normal state, attention is drawn to the temperature at the point of inflection $d^2r/dT^2 = 0$, the temperature of the point of proportionality $dr/dT = r/T$, and the temperatures of the minimum $dr/dT = 0$. The investigation of these points is only possible by the aid of liquid hydrogen. Only in some cases—and even then the purity of the metal is open to doubt—the point of inflection, whose existence was indicated by Dewar, was found high enough to be ascertained without measurements for hydrogen temperatures. For metals in the purest and normal state the point of proportionality lies probably below the temperatures which are to be reached with liquid hydrogen. Our measurements indicate that as a metal is brought to a purer and more normal state, the point of proportionality is found to be lower. The metal wire which came nearest to the ideal state was one of our gold wires. Even at the lowest temperature the point of proportionality was not yet reached for that wire. Probably Dewar's wires were further removed from this ideal state.

Gold—The different samples of pure gold were all supplied by Dr. C. Hoitsema. With two exceptions the wires were all treated in exactly the same way, drawn out by Heræus to 0.1 millimetre diameter, and treated at every pull with dilute sulphuric acid and nitric acid. The gold wire Au_{VI} was drawn in a different way and made very impure. The exact amount has not yet been ascertained.

The wire Au_0 contained 0.03 per cent impurities. As to the wires Au_{II}, Au_{IV} and Au_{VI}, Dr. Hoitsema found about 0.015 per cent admixture for Au_{III}, and about 0.005 per cent admixture for Au_{IV} and Au_V. Au_{Ag1} was made of an alloy which, after the wire had been remelted, contained 0.4 per cent admixture (probably chiefly silver). Wound round the same glass cylinder, all wires except Au_0 and Au_{Ag1} were heated at the same time in an annealing furnace for a long time, and slowly cooled, as had also been done with Au_0 and Au_{Ag1}, so that they were perfectly malleable. Table I gives some of the results obtained, the resistances being expressed in terms of 0 degree as unity.

TABLE. I.

Temp	$Au_{III.}$	$Au_{IV.}$	$Au_{V.}$	$Au_{VI.}$	$Au_{0.}$	$Au_{Ag1.}$
0°	1	1	1	1	1	1
−103 88	0.59601	0 59389	0.59306	0.64827	0.60545	0.64549
−183.00	0.27653	0.27177	0.27096	0.37053	0.30070	0.37099
−2 5.34	0.14058	0.13407	0 13337	0.16822	0.16081	....
− 252.93	0.01602	0.008743	0 008103	0.13069	0 01554	0.13342
−2 8.81	0.01095	0.004265	0.003600	0.13241	0.03982	0.13288
[−261]	....	....	0.002713	....	....	....
[−262]	....	0.002257	0.002526	....	....	....

To facilitate comparison we may observe that Dewar found 0.03290, whereas we found 0.008103 at — 252.93° for Au_V.

Some of the figures for mercury, silver and lead are given in Table II. The mercury was doubly distilled, the silver contained 0.18 per cent impurity, and the lead probably not more than 0.015 per cent.

TABLE II.

Mercury.		Silver.		Lead.	
Temp.	Resistance.	Temp.	Resistance	Temp.	Resistance.
0°	97.126	99.76°	1.41089	+ 16.33°	1.0652
−183.00	7.2650	0°	1	0°	1
−197.87	6 0103	−103.81	0 58087	−103 63	0.59548
−205.01	5.3900	−183 57	0 24679	−183.65	0.29439
− 215 34	4.5057	−204 67	0 15528	−216 61	0 17129
−252.93	1.2613	−252.92	0.008913	−255 07	0.02314
−258.81	0.7534	−259 22	0.006042	−258.70	0.01311

International Electrical Exposition at Marseilles.

An international exposition of the applications of electricity will be opened at Marseilles, France, April 19, 1908, and will run until October 31. This is under the patronage of the municipality and of the Chamber of Commerce of that city.

The exposition will be held at Parc du Rond-Point du Prado. Departments for all applications of electricity have been created. The exposition will be under the direction of General Commissioners H. Dubs and G. Cordier. The direction of the foreign division of the exposition will be conducted by E. Thurnauer. Offices have been opened at 52 Boulevard Louis-Salvator, Marseilles, and 63 Boulevard Haussmann, Paris.

[1] Extract made by the *Electrician*, London, of a paper read at the Royal Academy, Amsterdam, September 28, 1907.

American Institute of Electrical Engineers.

The two hundred and twenty-third meeting of the American Institute of Electrical Engineers was held in the auditorium of the Engineering Societies Building, New Yark, December 13, when three papers dealing with several problems of power-house operation and design were read and discussed. The first to be presented was by Walter S. Finlay, Jr., entitled "The Ratio of Heating Surface to Grate Surface as a Factor in Power Plant Design." The author discusses the problem of selecting suitable boilers and furnaces, and presents a number of curves, showing how the various factors entering into the problem are affected by the load-factor. He then describes an interesting boiler setting adopted for eighteen boilers in the Fifty-ninth street station of the Interborough Rapid Transit Company, of New York. A second furnace was added to each boiler, under the mud-drum, the new stoker having an area about eighty per cent of that of the old. Both stokers are of the Roney type. The author gives the results of firing with both of these furnaces and compares the performance of the boiler when thus operated with its original performance with the single furnace. The output of the boiler was considerably increased, while its efficiency remained practically constant. This arrangement should effect a considerable saving in boiler-room area and hence reduce a number of factors entering into the cost of the installation. The cost of the boiler house itself may be reduced about forty per cent; the boilers may be reduced fifty per cent; the piping forty per cent; the cost of the stokers remains the same, there being two to each boiler; the coal-handling apparatus may be reduced fifteen per cent in cost, due to the condensation of the boiler room; the remaining factors of the boiler house will not be changed. This results in a total cost of the boiler house of $101.47 per kilowatt of station output. The cost for a single grate equipment for an equivalent output was estimated to be $125 per kilowatt output of the station, showing that altogether a saving of 19.6 per cent of the first cost of the plant is made by the double-furnace arrangement. For a plant costing, with a single boiler equipment, about $150 per kilowatt output, a saving of 20.8 per cent will be made by using the double-furnace arrangement.

The second paper, by Henry W. Wait, was entitled "An Exhaust Steam Turbine Plant." This describes in some detail the exhaust steam turbine and steam accumulator installed in the Wisconsin Steel Company's mill at South Chicago. This is probably the first application of the Rateau low-pressure turbine and steam accumulator or regenerator in this country. The steam used comes from a double-cylinder engine of the rolling-mill type, the cylinders being forty-two by sixty inches. The work is rather irregular, but the engine is stopped or practically idle twenty per cent of the time. The average horse-power when actually running is a little over 1,000, while the average if distributed over the entire time would be 820. Figuring back from the total steam consumption, it was found that the engine uses sixty-four pounds of steam per average indicated horse-power per hour, or fifty-four pounds during the actual running.

The steam accumulator and accessory appliances are described in considerable detail, as are also the turbine and the generators which are directly coupled to it. These are direct-current machines of the usual type, built somewhat solidly, and are provided with commutating poles to adapt them to steam turbine speeds. Each machine is rated at 250 kilowatts, the pressure developed being 250 volts. The author gives curves showing the performance of this steam unit turbine system and says that the general result of the installation was that it has enabled the mill to shut down two 250-kilowatt engine-driven generators which formerly operated the mill and for a long time the turbine carried the entire electrical load. Recent additions of more electrically driven machinery have made it necessary to run one of these older units occasionally to help out the turbine. It is estimated that the total cost of the power produced by the turbine is 0.299 cent per kilowatt-hour; the fixed charges used in computing this cost are on a basis of $80 per kilowatt. The total operating expense of the turbine is said to be 0.087 cent per kilowatt-hour, no charge being made for the steam utilized. The author points out that the low-pressure steam turbine and accumulator are suitable for other classes of work and should give particularly good results when used in connection with large mining hoists, where the load on the engine is irregular. He points out that also a great saving can be effected in connection with continuous-running engines, as such a system may be used to increase the power of such engines, even when running condensing.

The third paper was by C. O. Mailloux, and was entitled, "The Westover Carbon-Dioxide Recorder." This discusses the advantages of checking boiler performance by watching the percentage of carbon-dioxide in the flue gases. The Orsat apparatus is described and the one developed by H. J. Westover. The latter embodies some new features desirable from the point of view of the boiler-room manager, which are intended to make it somewhtt rugged mechanically and do away with the necessity of technical knowledge on the part of the attendant. The author points out that one of the lessons taught by the carbon-dioxide recorder is the necessity for more frequent adjustment of the furnace damper and the adjustment should usually be less at a time than heretofore. Admitting the necessity for this, the question of finding means for doing it properly and cheaply is assuming some importance. The automatic damper control should be valuable, and the logical way to control this would be by means of the carbon-dioxide recorder. To do so is not easy, but the results which have, up to this time, been attained in an attempt at solution are encouraging.

The papers were discussed somewhat fully by those present, and a number of written communications were received which could not be read due to the lateness of the hour. The discussion was opened by Dr. J. A. Holmes, of the United States Geological Survey, who has been in charge of the fuel tests begun at the St. Louis Exposition, which have been carried on by the department since that time. Dr. Holmes did not take up specifically any one of the papers which had been read, but dwelt somewhat at length upon the general question of fuel economy; the importance of this to the country; the danger of exhausting our supplies; the possibilities of utilizing fuels which are now neglected; and he showed that one of the most important problems confronting us is to bring the general public to a realization of the necessity for economy in the use of fuels. He showed also what steps the Government is taking to develop and preserve our fuel resources, particularly the forests which are so heavily damaged each year from fires.

Dr. Charles E. Lucke discussed Mr. Finlay's paper somewhat fully. He did not agree entirely with the author that the boiler efficiency of the two-furnace installation is the same as that of the single-furnace arrangement. He pointed out that the addition of the second furnace should increase the temperature of the escaping flue gases. This, of course, means a decrease in boiler efficiency. He

did not see how burning seventy-four per cent more coal under the boiler could be done without some change in the boiler efficiency. If this were actually the case it would constitute a criticism of the furnace, and not of the boiler, so that the former should come in for a critical examination.

Albert A. Cary also discussed Mr. Finlay's paper at considerable length, dealing particularly with the effect of varying the area of the grate. He explained his method of designing boiler plants, which consists in starting at the furnace, designing this to burn the required amount of fuel, and then fitting the boiler to the furnace. The usual method is to select a boiler and then build a furnace to go with it. He gave results of a number of boiler trials, showing how attention to the design of the furnace affected the efficiency of the installation. In concluding his discussion, Mr. Cary described a two-furnace boiler-setting which he had designed as a modification of a suggestion he had seen ten years ago.

J. P. Sparrow thought that in Mr. Finlay's paper undue prominence had been given to the question of grate area. There is considerable variation in this matter in common practice. The ratio selected should, of course, depend upon the character of the load. He thought that Mr. Finlay's comparison was hardly fair, since he had taken a good performance of the double-stoker arrangement and a poor performance of the single stoker. The New York Edison Company has been conducting tests of furnaces where the rate of combustion is high, the results of which compared very favorably with those given by Mr. Finlay. By means of forced draft forty-four pounds of coal have been burned per square foot of grate surface per hour. He thought that in electric-lighting stations it is good practice to operate boilers at about fifteen per cent above the rating and then to force them to carry the peaks of the load. The keynote of the situation lies in the increase of the rates of combustion, as this bears the same relation to construction and fixed charges as Mr. Finlay's increase of grate area.

J. E. Moultrop discussed the paper in much the same way, asking why it was that so little coal was burned on the single stoker. An inspection of the results seems to indicate that the return of combustion might have been increased, but probably not by installing a second stoker. He calls attention to some of the changes in the design of the furnace necessitated by the addition of the second stoker, and thought that some of these changes might be beneficial, even were the second stoker not put in. Some of the new furnaces and the boilers of the Edison Illuminating Company, of Boston, have been redesigned: the boiler has been raised fifteen inches higher than is usual; the stoker has been dropped nine inches and brought forward something over three feet. This gives a long ignition arch and a large combustion chamber and makes possible an economical increase in the rate of combustion.

W. F. Wells said the ratio of heating surface to grate surface, although important, is a matter of secondary consideration. The first consideration should be given to the evaporation possible per square foot of heating surface consistent with commercial economy. Having determined this you can work back to the furnace and design that to burn the required amount of fuel. He described the changes which have been made in some of the furnace settings of the Brooklyn Edison Company's Sixty-sixth street station in which the furnaces were extended and the grates enlarged. This, however, has been done not so much to increase the evaporation as to give increased economy. Similar changes have also been made at the Gold street station.

Mr. Finlay closed the discussion, saying with regard to Mr. Moultrop's suggestion that the furnace itself be increased, that this could not be done with the Roney stoker. The combustion on this stoker can not be carried further than it is at present. He did not agree with Mr. Sparrow that undue prominence had been given to the size of the grate surface, as he stated particularly that this was simply one method of attacking the problem of combustion. He thought Mr. Wells's statements also were in full agreement with his discussion. Professor Lucke's criticisms, he thought, were chiefly theoretical and were answered fully by Rankin's theory of heat exchange taking place in the boiler.

A number of written discussions were received, which, due to the lateness of the hour, were presented by name only, and the meeting was adjourned. A brief reference to each of these is given below:

Francis Hodgkinson submitted a discussion of Mr. Wait's paper, pointing out that the low-pressure steam turbine can not be expected to give equally good results everywhere. However, low-pressure turbines can be made to operate with steam at less than atmospheric pressure, and when thus used might show considerable saving even with the more efficient types of engine.

Walter T. Ray and Henry Kreisinger contributed a discussion of Mr. Finlay's paper in which the authors held that the empirical rules now used in designing boiler settings are hard to justify, that the possibilities of increasing the rate of heat transmission into boilers should be considered and the thing to do is to work the boilers harder. The boiler is an efficient heat absorbent and if the problem of forcing the furnace efficiency is solved, the boiler will do its part.

W. L. Abbot also discussed Mr. Finlay's paper, expressing a difference of opinion in some points. He did not think that sufficient allowance had been made for the loss of fuel nor for the economizer. He pointed out that in many cases the size of the power-house is not determined by the number of boilers, and that the saving which Mr. Finlay allowed for this seemed to be too large.

A. Bement said that there has been a growing realization of the advantages to be obtained from having available a large furnace capacity. He thought it was remarkable that the efficiency of the installation described by Mr. Finlay should be varied so slightly by the addition of a second furnace.

J. R. Bibbins pointed out some of the features touched upon by Mr. Wait, dwelling upon the difficulty of conducting tests of low-pressure turbines, particularly with respect to measuring the steam consumption. He thought that low-pressure steam-turbine application resolves itself into two general classes: those in which the turbine uses the same quantity of steam as the primary motor, and those in which it is unable to do this. A peculiar instance of the first class is that of driving alternators by means of low-pressure turbines, the alternator being connected in parallel with that of the primary motor. In such cases no governor is needed upon the steam turbine except to prevent it from running away if the load is thrown off the turbine alternator.

F. V. Henshaw, referring to Mr. Finlay's paper, pointed out that neither heating surface nor grate surface can have fixed values for different designs. They must be considered in connection with specific cases. He emphasized the fact that the efficiency of the furnace may be greatly modified by a slight change in the baffling surfaces. Engineers who have explored furnaces by means of thermocouples have frequently found dead points where the boiler heating surface is practically idle. He thought that in general the boiler plant offers the most promising field for improvement in power station work and that the invention of a practical carbon-dioxide recorder is a great help in this respect.

REVIEWS OF CURRENT ENGINEERING AND SCIENTIFIC LITERATURE

Variation of a Mass of Electrons in the Interior of the Atom.

A short discussion of the possible variation of the mass of electrons has been contributed to the French Academy of Sciences by H. Pellat. The author considers the effect of the magnetic field set up by each electron, due to its motion, upon neighboring electrons. These fields are at right angles to the plane in which the electrons move, and may be considered to be of sufficient intensity to affect a neighboring electron appreciably only throughout a limited area around the electron which sets it up. If these fields overlap, each electron will exert a force upon the other which may tend to accelerate or to retard its motion. It is shown analytically that the direction and amount of this action depend upon the distance apart of the electrons and that the effect increases as they approach, reaching a maximum, and then again decreases. He points out that this may explain the phenomena noticed by Zeeman and Becquerel, which seem to require for their explanation the assumption that the corpuscles of an atom possess different masses. Of course, according to the electron theory, the mass of a corpuscle is a function of its velocity, and if the velocity be changed, as has been suggested, the mass will naturally vary in the same way.—*Translated and abstracted from L'Eclairage Electrique (Paris), November* 30.

Sensitiveness of Metal-Filament Lamps to Current Variations.

A brief note, communicated by Herr Niethammer, calls attention to some observations which he has made respecting the behavior of metal-filament lamps on unsteady supply circuits. He says that variations of one or two per cent, and even less, are noticeable to the eye, particularly when the lamps are operating from alternating-current systems, where batteries are not used for steadying the pressure. This is explained, as is well known, by the thinner filament, as compared with carbon, and its small heat capacity. To avoid the flickering it will be necessary for central stations supplying metal-filament lamps to maintain a more constant potential than when carbon lamps are used, if batteries are not employed. Moreover, the intensity of the metallic filament varies noticeably on alternating currents of low frequency, which may be shown clearly in the following way: It is well known that the slippage of an alternating-current induction motor may be shown clearly if a white cross be drawn on a disc attached to the rotor of the motor and lighted from an arc lamp supplied from the same circuit. The cross then viewed appears to turn backward. Replacing the arc lamp by an ordinary twenty-five-candle-power carbon lamp causes the cross to disappear, as the variation in candle-power of the lamp is not sufficient to bring it out in relief. If, however, a metal-filament lamp of the same candle-power be substituted for the carbon lamp, the movement of the cross is clearly seen.—*Translated and abstracted from Elektrotechnik und Maschinenbau (Vienna), November* 24.

Cost of Operation of Steam-Turbine and Gas-Engine Stations.

Some estimates are given here by Leonard Andrews of the costs of gas-engine and steam-turbine plants. The size considered is one with a rating of 16,000 kilowatts. The output at this station is assumed to be about 13,000 kilowatts, to handle which properly, with steam turbines, requires 4,000 kilowatt units. The author estimates that the cost per kilowatt of a steam-turbine plant of these dimensions, after allowing for all auxiliary apparatus and contingencies, is $65.50. Such a plant would be able to carry an overload of fifty per cent for a short time. To do the same work with gas engines an equipment consisting of eight 2,000-kilowatt engines, each able to carry ten per cent overload, would be satisfactory. The relative costs of running the two systems are worked out and it is found that the gas-engine plant will produce one kilowatt-hour with a net cost of fuel of 0.085 cent. The cost of repairs to this plant would amount to 0.022 cent per kilowatt-hour for the generating plant and 0.011 cent for the producer maintenance; the cost of labor to 0.031 cent. The cost of oil and stores is 0.008 cent and the interest and depreciation 0.103 cent. This brings the total cost of operation per kilowatt-hour for the gas-engine plant to 0.267 cent, while that of the steam-turbine plant is found to be 0.41 cent. The author then calls attention to the advantages of gas engines when operated in connection with steam turbines, an arrangement which permits much of the heat loss of the gas engine to be saved and utilized by the turbines. He thinks that future competition in electrical heating plants will not be between turbines and reciprocating engines, nor between turbines and gas engines, but between reciprocating engines, with exhaust turbines, and turbines combined with gas engines.—*Abstracted from the Electrical Engineer (London), November* 29.

A Registering Electric Seismograph.

A description is given here by R. Goldschmidt of a registering electric seismograph which has been devised for the observatory of the University of Brussels, Belgium. An objection to the seismograph of the ordinary type is that the presence of an observer in its immediate vicinity may influence its action. This objection is removed if a device can be made to produce its record at a distance. For this purpose the present instrument was constructed. It consists of a heavy weight suspended by a wire in the usual manner. From the sides of this project four small bobbins of copper wire wound on iron cores, these being placed ninety degrees apart in the horizontal plane, the windings of the opposite bobbins being connected in series. Opposed to these coils, but supported on a rigid frame carried on the ground, are four other bobbins arranged so that the distance separating them from the coils on the weight may be adjusted nicely. Through the former coils are passed small alternating currents, which induce similar currents in the coils on the bob. This effect sets up mechanical forces tending to repel the suspended coils; but since the action is opposite on the two sides, the effect is neutralized. The intensity of the current passing through the fixed coils, or, rather, it should be said, the coils supported from the ground—since it is really these coils which move when the instru-

ment is in operation—depends partly upon the mutual induction existing between these coils and the opposed suspended coils. This induction varies, of course, with the distance separating the two coils of each pair, so that when a movement of the ground causes a relative displacement between these coils, the currents will be caused to vary. These variations in current may be used for registering the motion of the earth, at any convenient point, the currents being passed through suitable galvanometers or other devices. This arrangement resolves the horizontal motion of the earth into two components, which are registered continuously on a roll of paper. A vertical movement can, if desired, be registered in the same way by placing another pair of coils in a vertical position.—*Translated and abstracted from the Bulletin of the Société Belge D'Electriciens (Brussels), November.*

A Modern Garage.

A modern garage has been opened in London by the Electromobile Company, which is probably one of the most complete institutions of its kind. The building is eighty feet wide and 350 feet long, and comprises a basement, ground and second floors, with an asphalt roof, which is used for washing cars in summer. The entire structure is of steel and concrete. Telephonic communication is provided throughout the entire building. The carriage entrance is on the ground floor, where there is an office for the timekeeper and yard-foreman and a telephone box, and immediately opposite this are two hydraulic lifts for removing the batteries from the car. The cars, as they come in, are run over the elevators, which rise from below, containing a low truck. The batteries are dropped from the car and lowered to the basement, where they are wheeled into position for recharging. The car is then run on a traveling platform, by means of which it can be transferred to any part of the building. There are three hydraulic elevators for carrying cars to any of the floors of the building. On the first floor there are two transfer tables to serve all parts of the floor, taking the cars to the repair shop or to the inspection pit. The latter is a long pit bridged by a number of steel channels placed so as to accommodate the wheels of the cars. Thirty cars can be inspected at once on these pits and the repair men can pass easily to any part of the pit. In one part of this floor there is a steel door mounted in sections, which enables any body to be lifted off the chassis. The dynamo room is in the basement and contains three ninety-kilowatt motor-generators and one of thirty kilowatts. Each generator is capable of developing 140 volts, though the usual maximum is 115. The motors of these units are compound-wound and both motors and generators are provided with field regulators. A complete switchboard is provided for these machines. The batteries used on the cars consist of forty-five cells, having a capacity of 160 ampere-hours with a thirty-ampere rate of discharge. Each cell weighs twenty-two pounds. They are contained in ebonite boxes and the whole included in an iron-bound teak crate, weighing in all 1,100 pounds. The system for watching the performance of the batteries has been worked out elaborately. Commencing with the charge of the battery, a card is filled out, on which is recorded the voltage on open circuit and the voltage on closed circuit at the end of the charge. This card accompanies the battery, and on it are noted the time of leaving the garage, the driver of the car, and the customer. Upon its return the battery is tested for open and closed circuit-voltage and current, which are noted on the card, as well as the number of miles made by the car. These cards are kept on file, thus giving the complete history of each battery; and they also enable the life of the tires to be determined. It is found that the cost of operating these cars on a basis of two miles per kilowatt-hour is less than two cents per mile for the energy, and that the cost of maintenance of the batteries is less than that of the tires.—*Abstracted from the Electrical Review (London), November 29.*

Electromagnetic-Brake Tests at Leeds, England.

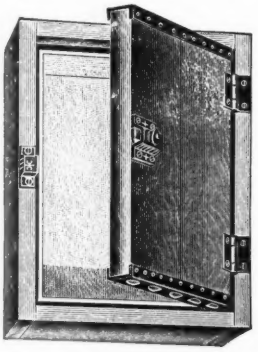
Some interesting tests of a new electromagnetic brake have been made on the Leeds (England) Corporation Tramways. The trials were made with a double-deck car on a hill about a quarter of a mile long, the steepest portion of which was at a grade of one in 8.4. It was at this point that the trials were made, this stretch of the track being about one furlong in length. The brake consists of a magnetic track brake placed between the two wheels of the truck and linked mechanically to two other track brakes placed between the magnetic brake and the wheels, and rather close to the latter. These are connected by links to the axle boxes and by a toggle to arms extending from the support of the magnetic brake. The latter is brought into action either by throwing it in circuit with the motors caused to run as dynamos, or by connecting it directly across the trolley; while, if both of these sources of current should fail, it is possible to apply the two other track brakes mechanically. The object of this arrangement is to use the electromagnetic brake in conjunction with the motors for all service stops. This arrangement is also suitable for emergency braking and for drifting down grade. Should this power fail, a switch on a canopy of the platform allows the motorman to use the system as an emergency brake. The manual arrangement of applying the brakes may not only be used effectively in case both other methods fail, but it is a suitable way for applying the brakes for controlling the speed on down-grades. A large number of tests have been made with this brake, which seem to indicate that it is unusually effective. When this car was running down hill at a speed of 22.5 miles an hour an attempt to control the speed without applying the track brake was not successful. This was done by utilizing the braking power of the motors, but the wheels skidded almost continuously for about 150 yards, until the bottom of the hill was reached. With a lower speed of nineteen miles an hour the same result was obtained. With the car going down the hill at 11.6 miles an hour, the mechanical brake, operated by the canopy switch, brought it to a stop in 104 feet. At fifteen miles an hour the car was stopped in 229 feet. The current taken by the magnet was thirty-nine amperes. With the car running at eighteen miles an hour, and the brake operated from the motors only, the former was brought to a stop in sixty-four feet. At 25.5 miles an hour it was brought to a standstill in 198 feet. With this arrangement the maximum kick of the ammeter in circuit with the motors in the brake was 110 on the scale. Running down the hill with the manual brake applied so as to control the speed, bringing the electromagnetic brake into action, brought the car to a very sudden stop. Some of the advantages claimed for this brake are the avoiding of the wear on the car wheels, the absence of heating of the latter, and the fact that when the brake is applied to the track it takes part of the weight off the wheels and thus limits the current which may be drawn from the motors by the brake.—*Abstracted from the Electrician (London), November 29.*

INDUSTRIAL SECTION

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS

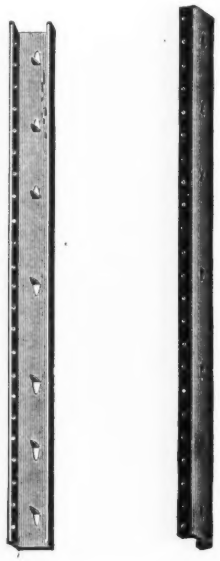
A New Line of Wood Cutout Cabinets.

A new line of wood cutout cabinets, manufactured by the Ashland Electric



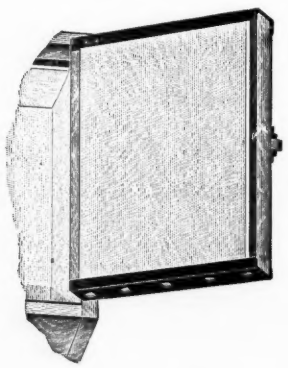
OUTSIDE VIEW OF CABINET, SHOWING METAL CLIP WITH PERFORATIONS.

Company, 195 West Division street, Chicago, Ill., is shown in the accompanying illustrations. These cabinets are solidly built and lined with asbestos, so as to



INSIDE AND OUTSIDE VIEWS OF METAL CLIP.

meet the severest requirements. Metal clips are provided, fastened to the top and bottom of the door, which not only prevent the latter from warping, but insure its always fitting snugly in the box. The illustrations show the construction of these clips and the method of attaching them to the door. The boxes are made in various



INSIDE VIEW OF CABINET DOOR.

sizes, from eight by six by three inches up to twelve by thirty by three inches.

The "Ideal" Band-Saw Sharpener.

The accompanying illustration shows a band-saw sharpener intended for the use of smaller factories where the more expensive automatic sharpeners are seldom available. Factories which have occasion to sharpen but one or two saws a week can not afford to install expensive sharpeners, and still rely largely upon hand-sharpening. The "Ideal" sharpener is intended to fill the wants of such users.

The operation of the sharpener is automatic, in that, at each revolution of the file shaft, the rotary file is drawn back from engagement with the tooth, automatically dropped back, and just as the smooth portion of its circumference reaches the saw, it moves the saw along for the next tooth. The amount of this movement is regulated by the size of the saw-tooth, through a thumb-screw. The file cuts to a certain depth only at each revolution, a feature which insures accurate and even teeth.

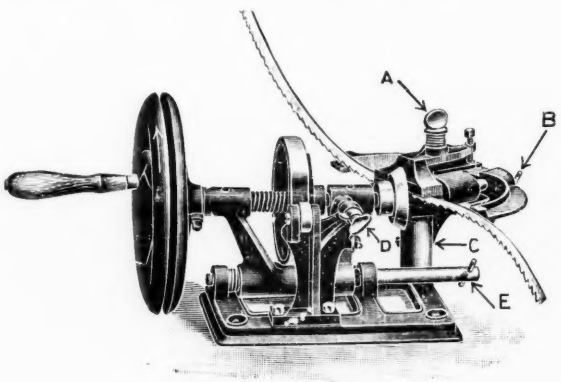
Although the vise grips the saw sufficiently rigidly for sharpening, the jaws are held together by spring pressure, which allows the saw to slip through them in order to bring the next tooth into position. This feature also permits saws with uneven or thick welds to be sharpened without any trouble.

The design of the sharpener has been made as simple and durable as possible. The operation is simple, as all that is necessary is to place the saw in the vise and start the machine. The maker states that its use saves from one-half to three-quarters of the time required to sharpen saws by hand.

The "Ideal" sharpener is manufactured by the Rotary File and Machine Company, 589 Kent avenue, Brooklyn, N. Y.

Great Northern Railway Orders Electric Locomotives.

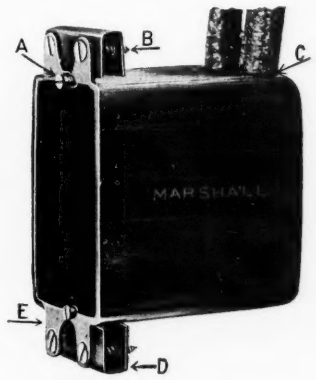
The Great Northern Railway Company has placed orders with the General Electric Company for four 100-ton electric locomotives for hauling trains through the Cascade Tunnel, in Washington. Each locomotive will be capable of hauling a 1,000-ton train at a speed of fifteen miles per hour on a two-per-cent grade. The installation will be the first to employ three-phase motors for railway service in this country, and it is stated that the locomotives will be much larger and more powerful than any now used on European three-phase roads.



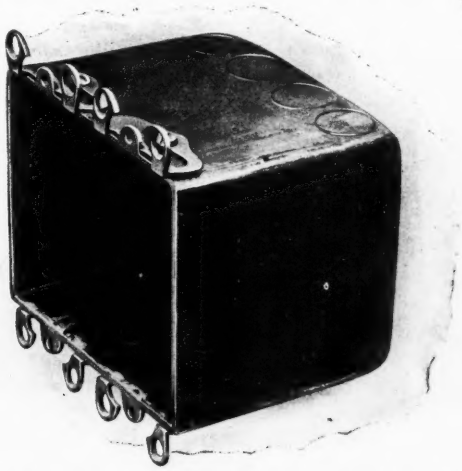
THE "IDEAL" BAND-SAW SHARPENER.

The "All-in-One" Wall Cases.

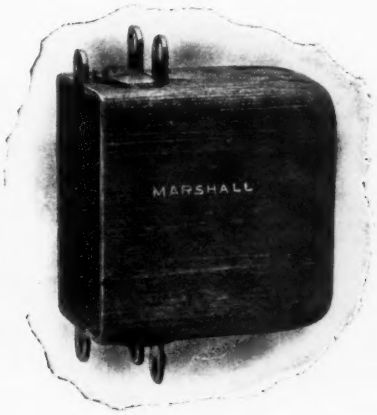
The great increase in the use of flexible ducts in construction work during the last few years has created an insistent demand for switch and wall cases adapted to all sorts of conditions. To meet this demand the manufacturer of the "All-in-One" wall case has made a very careful study of constructors' demands, getting the opinion and advice of hundreds of the most important contractors in this country. The result has been a system of wall cases adapted to a very wide range of requirements, which are illustrated by the four different styles shown in accompanying illustrations. These show single and two-gang boxes. The boxes, however, are made up to four gangs, and five and six-gang boxes are being prepared.



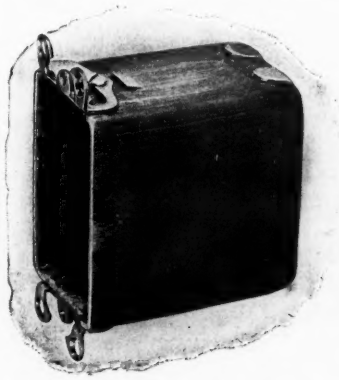
"All-in-One" Wall Case for Flexible Textile Ducts, for Work in Old Lath and Plaster.



Wall Case for Flexible Textile Duct for Work in New or Old Lath and Plaster.



Wall Case, with Lugs, Adjusted for Flexible Textile Duct Work in New Plaster.

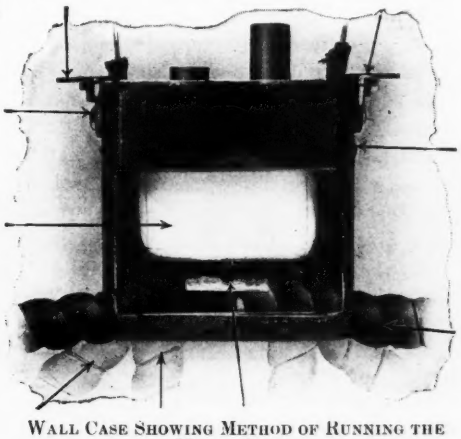


Wall Case for Flexible Metal Duct.

This line of wall cases fits all standard switches now on the market. The cases are novel, being drawn from a solid piece of steel. The fastening ears, on all but the adjustable-lug boxes, are made from the same piece of steel as the wall case.

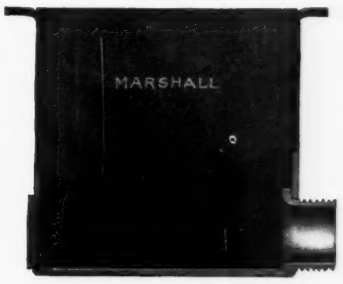
Wall cases Nos. 1475, 1476, 1477, 1478 and 1479 are particularly adapted for "Circular Loom," "Flexduct," etc., for use on old lath and plaster work. They fit all standard switches now on the market. The lugs or ears on the wall cases are drawn flush with the top, and as they sink into the plaster bring the plate in the right position when finished. They are provided with eight knockout holes, four in the bottom and two in each end. Locking clamps are provided when ordered. A spacing block is provided where it is desired to dig the plaster away and attach the ears directly to the lath.

Wall cases Nos. 1745, 1746, 1747 and 1748 are suited for all styles of flexible textile conductors, as "Flexduct," "Circular Loom," etc. They are provided in place of the fixed flush lug with an adjustable lug. The bottom of the lug is flush with the bottom of the wall case, allowing the former to extend into the plate when used for old work. If it is desired to use it for new work, loosening one screw permits the immediate reversal of the lugs into the seven-eighths-inch position, where they are securely locked in place by a half turn of the same screw. There is no opportunity for losing the screws and pins, and the adjustment is made in a few seconds. These cases are provided with knockouts in the ends and the bottom, and with locking plates when so ordered. They will fit any standard switch now on the market.



Wall Case Showing Method of Running the Metal Duct.

Wall case No. 1731 is especially novel in its construction, and is designed particularly for B-X cable and flexible metal ducts. It is provided with an adjustable lug for old or new work the same as No. 1475, but the knockouts are made diagonally through the corners of the box so that the flexible metal duct, which will bend only on a fairly large radius, can be drawn through a two-inch by three-inch hole in a partition. This is accomplished by pulling the duct through the bottom of the case. As it is pushed back into the wall the duct describes an arc through the corner of the wall case and is held flat on the bottom by a special round-edged clamp, answering the purpose of a bushing.



Wall Case for Stiff Pipe Work.

Wall case No. 1738 is adapted to special cases when stiff pipes are employed. It consists of a case similar to the others, except that there are no lugs or ears, as the box is held by the pipe. Through the ends

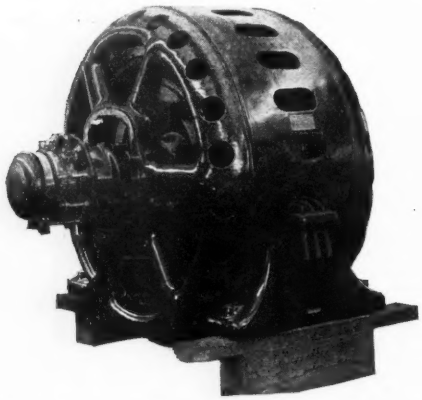
and the bottom are pierced knockouts that can be removed and into which a fixed nipple can be inserted, making an integral wall case which can be secured on the pipe coupling.

The wall case is the same size throughout, closely fitting the switch. It is particularly adapted to enameled brickwork and other situations where enlarged bottom wall cases can not be properly finished over.

These wall cases are manufactured and sold by the Marshall Electric Manufacturing Company, of Boston, Mass.

Induction Motors for Copper and Brass Rolling Mills.

The new plant of the Buffalo Copper and Brass Rolling Mills at Black Rock Station, N. Y., will be driven by means of induction motors supplied with power transmitted from Niagara. For driving the rolls three Allis-Chalmers motors will be used: one of 500 horse-power for the main rolls and two of 250 horse-power for the finishing rolls. All three motors are



Allis-Chalmers Induction Motor Installed at the Buffalo Copper and Brass Rolling Mills.

of the wound rotor type, designed to operate at twenty-five cycles, 2,300 volts. The 500-horse-power motor runs at 375 revolutions per minute synchronous speed and the 230 horse-power at 500 revolutions per minute. The motors are connected to the rolls by means of flexible couplings.

The illustration shows the 500-horse-power motor. The two 250-horse-power motors are of exactly similar design. The construction throughout is very substantial and suited to the exacting requirements of rolling-mill work. The stator coils are placed in open slots and held in place by wedges, so that they can be readily removed. The stator core is provided with numerous ventilating ducts to allow circulation of air through the core and windings. The end connections of the stator coils are securely held where they project beyond the core. The stator yoke is of box-frame construction, the laminations being held in place by dovetail projections on the punchings.

The rotor is provided with a three-phase Y-connected winding, connected to three cast-copper collector rings mounted on the shaft. The rings are outside the bearing housing so as to be readily accessible, the leads from the winding being brought through a hole in the shaft.

The rotor winding is made up of copper strip, having the conductors in the slots connected at the ends by involute end connections securely held in place by brass shields. The whole rotor construction is such as to give thorough ventilation of all parts. The bearings are of the ring-oiling, self-aligning type.

Each motor is provided with a cast grid secondary starting resistance with an oil-immersed controlling switch for cutting the resistance out of circuit and gradually bringing the motor up to speed. A small part of this resistance is designed for continuous service, and can be left in circuit.

B. J. Dashiells is consulting engineer in charge of the new construction and equipment, which will be used chiefly in the manufacture of copper sheets.

Novel Use of Electric Flat-Iron Heaters.

It is not often that heating units from electric flat-irons are put to as severe a test as in the instance given below. The problem was to replace a crank-pin on the high-pressure side of a 500-horse-power cross-compound Russell engine. The new pin was six inches in diameter, with a taper of one-sixth inch, and had to be fitted tightly into the disc, which was five inches thick with a twelve-inch shaft. To expand the disc by heating it with blow-torches would have taken too long, besides making a dirty and unsatisfactory job, so several heating units from General Electric six-pound flat-irons were grouped around an iron core three and one-fourth inches in diameter and placed in the six-inch hole in the crank-disc. In four hours after the current was turned on the disc had expanded sufficiently to allow the crank-pin to slip in. Although the heating units were at about white heat all of the time, they were not injured except that the brass tubing on two was slightly melted in one place. The heating units were afterward replaced in the flat-irons and have been in use for the last three months.

The Purchase of Small Supplies for the Navy Department.

To the Editor of the Electrical Review:

The Bureau of Supplies and Accounts, of the Navy Department, recently forwarded to certain manufacturers—160 in all—a circular letter explaining the recent improvements in the contract business of the Navy Department as regards: (*a*) waiving of bonds and contracts on proposals less than $500 in value; (*b*) unloading, at Government expense, deliveries at navy yards; (*c*) obviating delays in payment for deliveries made, and (*d*) abolishing ten-per-cent reservation from value of deliveries, etc., with a view of encouraging competition, thus eliminating certain objectionable features of bidding.

This letter has been given widespread attention through certain mediums—trade journals, jobbers' associations, etc.—and the impression has been created and disseminated broadcast throughout the country that the bureau intends to confine competition to manufacturers only, by refusing to consider bids from the wholesaler, jobber, retailer and middleman.

The bureau has neither the desire nor the power to exclude any reputable dealer from bidding on naval supplies. All bids from such persons will be given the same consideration, and in each case award will be made to the lowest formal responsible bidder. By reason of the onerous requirements under the old form of contract many responsible firms were unwilling to deal directly with the bureau. By removing these onerous conditions it is hoped that such firms will bid directly for the navy business, and, by thus widening competition, give to the navy better prices and prompter deliveries.

E. B. Rogers,
Paymaster-General, U. S. N.
Navy Department,
Washington, D. C.

New York Section of the American Electrochemical Society.

The following was the programme arranged for a meeting of the New York section of the American Electrochemical Society, held December 17, at the Chemists' Club, 108 West Fifty-fifth street, New York city:

Lawrence Addicks, superintendent United States Metals Refining Co., Chrome, N. J., "The Refining of Copper."

Harold Martin, formerly of the Chloride Accumulator Company, "Modern Developments in the Storage Battery."

Special Lighting of Down-Town Streets.

This topic, as discussed by the Chicago section of the Illuminating Engineering Society on December 12, was well timed, owing to the endeavors of the Dearborn Street Improvement Association to find a way of so lighting Dearborn street as to make it unusually attractive in the evening. The committee, headed by Alderman Taylor and aided largely by J. R. Cravath, who had volunteered his services as illuminating engineer, had been grappling with the problem for some time, knowing that it was one which would mean a precedent for other business streets, both at Chicago and elsewhere.

The reports obtained from various other points, where special lighting had been secured by the merchants for down-town streets, showed a wide range of practice, varying from sixteen-candle-power incandescent lamps on posts or arches to arc lamps placed two on a post. In every case the consumption of power per lineal foot of street was far in excess of that required for ordinary street-lighting purposes, as it was shown that in outlying districts a satisfactory street lighting could be obtained with only two watts per lineal foot of street. In the more notable instances which have come up during the past year or two, a consumption of from ten to twenty-two watts per lineal foot has been required, thus implying an intensity of illumination far in excess of that needed simply for the prevention of crime or for facilitating travel.

Incandescent lamps, when used in clusters on posts, as at Los Angeles and St. Paul, had been found to give an unusually uniform illumination of the streets and the building fronts, as was pointed out by W. H. Blood, Jr., in his paper on street lighting at the July convention of the Illuminating Engineering Society. However, it was felt that such a use of incandescents could not give a sufficiently showy appearance to the street to make it contrast with other business sections, and particularly so in view of the greater brilliancy of some of the signs on the street. It was also pointed out during the discussion that the ordinary enclosed arc lamps, and even the luminous arc lamps, have become so commonplace that they can not be made to give any striking effect beyond the unusually intense illumination obtained when they were closely spaced. Nor were the gas-mantle clusters seriously to be considered after the object lesson given on North avenue, where the display lighting requires a regular avenue of gas posts, which would be out of the question on a street already fitted with trolley poles. R. W. Bingham, of the Welsbach Company, pleaded strongly for the use of inverted Welsbach mantles, on the ground that the light distribution from the inverted form of mantle, when used in pairs, was entirely horizontal; but unfortunately he could show no tests to prove his claim, and the distribution curve for such an inverted mantle, as presented by another speaker, showed an acorn-shaped figure with a decidedly downward preponderance of the light.

Tungsten lamps of forty candle-power, placed in clusters of five on posts spaced about fifty feet apart, had been considered, the original feeling of the committee being toward the use of high-efficiency incandescent lamps with a view to decorative effect. However, such a close spacing of the posts, in addition to the existing trolley poles, seemed inadvisable, and incandescent arches were barred because of their cumbersome appearance during the day.

The original aim toward an artistic effect was overruled on the ground that a business street had essentially different requirements from those of a boulevard, and that the aim should be to produce a striking and spectacular effect rather than an æsthetic one. For this purpose the flaming arc lamp seemed particularly adapted, owing to both the intensity of the light and the color which differentiates it from the common tint of either the ordinary enclosed arc lamps or the luminous arcs. According to last reports the sentiment was toward the use of flaming arc lamps eighty feet apart, on alternate sides of the street, the lamps being supported on extensions to the trolley poles so as to reduce the number of posts on the street. The advisable height of the lamp above the street had not been fully decided, but Mr. Cravath presented curves to show how raising the lamps would decrease the contrast in the intensity of illumination between points on the street close to the lamps and midway between the same. With the arc lamp twenty feet above the street, the ratio between the close and the midway points was about 6 to 1, with the eighty-foot spacing between the lamps. Raising the arcs to twenty-five feet reduced this ratio to 3.4 to 1; while a thirty-foot height would give a ratio of only about 2 to 1.

It was found that the city was willing to furnish the current if the Improvement Association would supply the equipment, but not for as large a number of lamps as would be required for the eighty-foot spacing. This may therefore be changed to correspond to the trolley poles already in place, giving one lamp for every 100 to 125 lineal feet of the street. Such an increase of the spacing would considerably increase the contrasts in the lighting on the street. To avoid this several means for spreading the distribution of the light from a flaming arc lamp are being considered, and the results obtained will be awaited with interest, as they have an important bearing on the use of flaming arc lamps for street-lighting purposes.

While no definite orders have yet been given regarding this Dearborn street lighting, in all probability the coming spring will find Dearborn street offering a new example in the way of street lighting for business streets.

The Chicago Automobile Show.

The exhibition of automobiles and automobile equipments recently closed in Chicago was the most comprehensive and extensive ever held by this industry. Three large buildings were completely filled by the manufacturers. These buildings were the Coliseum, Seventh Regiment Armory and Tattersalls.

The marked advance in the construction of trucks and utilitarian vehicles, and the light vehicles for city and town use, was a feature of great interest, as well as the application of electric storage cells in automobile construction.

In addition to the great number of general automobile exhibits the following electrical companies had booths:

The Standard Varnish Company, New York, was represented by Arthur Davis, manager of the manufacturing trades department of the Chicago office. This company distributed a well-made Russian-leather bill case as a souvenir.

The National Carbon Company, Cleveland, was represented by Wallace O'Connor. The various types of the "Columbia" dry battery, designed especially for automobile ignition service were shown.

C. F. Splitdorf, New York, manufacturer of spark coils and electrical ignition devices, had a comprehensive line of these equipments on view.

The National Battery Company, Buffalo, had a booth equipped, but owing to the illness of the representative in charge the exhibit was not opened.

The Electric Storage Battery Company, Philadelphia, was represented by G. H. Atkins, manager of the Chicago office, and a staff of battery experts from his office was present. The "Exide" type of storage battery, especially designed for automobile service, was shown.

Current Electrical News

DOMESTIC AND EXPORT.

MEXICAN LIGHT AND POWER COMPANY INCREASES CAPITAL—Seven per cent preferred stock to the amount of $2,400,000 has been issued by the Mexican Light and Power Company in London, England.

PAWTUCKET ELECTRIC COMPANY UNDER NEW CONTROL—At a meeting of the directors of the Pawtucket (R. I.) Electric Company, the company passed into the control of the Stone & Webster Company, of Boston. The plant is valued at about $2,000,000.

SOUTHERN PACIFIC COMPANY PLANNING FURTHER ELECTRIFICATION WORK—It is stated that the Southern Pacific Company is contemplating the electrification of its line through to Sacramento, Cal., in addition to the electrification of the Oakland ferry lines. It is estimated that a saving of thirty-eight per cent could be effected in this way.

PENNSYLVANIA TROLLEY MERGER—The merging of the street railway companies in York, Pa., and vicinity has been finally completed, under the name of the York Railways Company. The company has filed a mortgage for $10,000,000, with the Guardian Trust and Safe Deposit Company, of Philadelphia, as trustee, in the office of the York county recorder. It is purposed to float thirty-year gold bonds at five per cent to that amount for the construction of new lines and other improvements.

PLANS LARGE POWER PLANT—Donald Fletcher has applied for a franchise to construct pole lines on all the roads and highways in Pierce county, Wash. The application states that Mr. Fletcher is the owner of water-rights on Cle Elum river and Cle Elum Lake in Kittitas county. It is desired to develop water power for the generation of electric current for commercial purposes. The proposed plant will develop 110,000 horse-power. A market has been secured for part of this power. It is understood that the electric-power proposition is linked with the plans of the North Coast Railroad for operating trains over the mountains.

PROPOSED SUBWAY SYSTEM FOR SAN FRANCISCO—The people of San Francisco, Cal., it is stated, are to be asked what their wishes are regarding a bond issue for the purpose of constructing a subway system to relieve the present congestion of surface traffic. For more than a year many prominent men have been investigating the project, and affairs are now almost ready for the circulation of a petition to the board of supervisors, asking for the issuance of a sufficient quantity of bonds to cover the cost of such a system, or, at least, to defray the cost of the initial section of the road. Supervisor Matt I. Sullivan and Isidor Jacobs are supporting the project with the aid of many other business and professional men of the city. Four million and a half dollars is the estimated amount required to construct the system for all practical needs of the city at present.

MERGER OF ST. LOUIS LIGHTING COMPANIES—The Union Electric Light and Power Company, of St. Louis, Mo., a subsidiary of the North American Company, has purchased from E. M. Clark & Company, of Philadelphia, the Laclede Power Company, of St. Louis. This gives the company control of all the light and traction companies of the city. The Laclede Power Company operates the Edison Electric Illuminating Company, of St. Louis. The purchase was accomplished by the exchange of securities of the Union Electric Light and Power Company for the Laclede Power Company, which has $1,000,000 of capital outstanding and pays five per cent annually. Approximately $3,000,000 of Union Light stock was reported to have been given in exchange. The Union company increased its capital stock, on December 5, from $10,000,000 to $18,000,000. The company reported assets of $30,714,025.52, exclusive of the items covered by the increase.

PHILADELPHIA & WESTERN RAILWAY FILES LARGE MORTGAGE—The Philadelphia & Western Railway Company, which operates an electric line running out of Philadelphia, has filed a mortgage to the Trust Company of America as trustee to cover an authorized issue of $20,000,000 of first-mortgage five-per-cent bonds. Of this issue only $4,000,000 is immediately issuable, the balance being reserved for extensions, improvements, or additions. All the stock of the Philadelphia & Western is owned by a syndicate, of which George R. Sheldon and Mackay & Company are managers. These gentlemen are said to be behind the Equitable Electric Power Company, recently chartered for the purpose of supplying Philadelphia with electric light and power, and which purposes securing power from the large power plant of the Philadelphia & Western Railway Company at Beechwood Park, three miles west of the city.

NEW INCORPORATIONS.

JERSEYVILLE, ILL.—Improved Electric Railway Company. $200,000, in $10 shares. Incorporators: Dr. A. A. Shobe, S. L. Hill and William Embley.

SPRINGFIELD, ILL.—Gillespie Electric Railway Machine Company, Gillespie. $30,000. Incorporators: H. Bycroft, R. H. Isaac, H. W. Rice, G. W. Schmidt and S. F. Preston, all of Gillespie.

GUTHRIE, OKLA.—The Columbia Electric Company, of Oklahoma City and Chicago. $25,000. Incorporators: Arthur V. Allen and A. C. Allen, of Chicago; A. J. Mahan, of Oklahoma City.

WASHINGTON, PA.—McDonald Electric Heat and Power Company, at McDonald. $100,000. Incorporators: A. Valentour, W. H. Young, B. Frankle, G. W. Smith and D. L. Williams, all of McDonald.

CHARLESTON, W. VA.—Sheppardstown Electric Light and Power Company. $20,000. Incorporators: Samuel J. Hodges, Harrison Schley, E. H. Rhinehart, David Lemen, H. L. Snyder, of Sheppardstown.

PORTLAND, ME.—Calumet & Lac La Belle Traction and Power Company. To acquire and maintain all kinds of railroads, railways, etc. $500,000. President, James E. Manter, Portland; treasurer, Charles D. Fullerton, Portland.

SPRINGFIELD, ILL.—Littleton & Brooklyn Mutual Telephone Company, Littleton; $1,000; incorporators—Herman Yaap, John Crawford, John Day. The Clinton Gas and Electric Company, of Clinton; an increase in capital from $10,000 to $175,000.

ST. LOUIS, MO.—Baden Power Company. $2,000. To manufacture, distribute and deal in electric, steam and hydraulic power. Incorporators: Robert Gaylord, Chicago; George S. Gaylord, of Evanston, Ill.; James A. Seddon, Warren D. Harris and Samuel B. McPheeters.

NEW PUBLICATION.

MUNICIPAL AND PRIVATE OPERATION OF PUBLIC UTILITIES—The report of the Committee of Investigation to the National Civic Federation Commission on Public Ownership and Operation, prepared in pursuance of a resolution adopted October 5, 1905, when the committee was appointed and instructed to make a thorough and comprehensive examination into the subject and to prepare a full report of its findings, has been issued. The first of the three volumes—Part I, Volume I—contains the final conclusions of the committee and the general summaries of the evidence upon the various phases of the subject. The second volume—Part II, Volume I—is devoted to the reports of the experts upon conditions in the United States. The third volume—Part II, Volume II—is devoted similarly to the situation in Great Britain—the European country selected for investigation. The various reports were reviewed in the ELECTRICAL REVIEW as they were made public.

PERSONAL MENTION.

MR. J. F. MARTIN has been appointed district manager of the Michigan Bell Telephone Company, at Norway, succeeding A. A. Shephard.

MR. GEORGE F. BROWN has retired as treasurer of the Pullman company after thirty-six consecutive years of service with the company. Mr. Brown's son, Charles E. Brown, is secretary of the Central Electric Company.

MR. I. D. CONDICT, for eight years secretary and manager of the Dover (N. J.) Electric Light Company, has resigned. Mr. Condict is succeeded by W. H. Vorce, of Hartford, Ct., who has had a wide experience in the electric lighting field.

MR. G. FRANK FABER, formerly superintendent of the Elgin & Belvidere Electric Company, Chicago, Ill., who resigned December 1, will commence the duties of division superintendent of the Lyons (Ohio) Electric Railroad Company January 1, 1908.

MR. J. M. REPPLIER has been made district manager of the Doylestown (Pa.) district of the Delaware & Atlantic Telegraph and Telephone Company. This district includes Hulmeville, Langhorne, Newton, Wycombe, Buckingham and Plumstead.

MR. J. W. TAYLOR, traveling representative of the Beardslee Chandelier Manufacturing Company, Chicago, Ill., has accepted a position with Edward Miller & Company, of Meriden, Ct., at the company's Chicago branch, corner of La Salle and Lake streets, where he will be located after January 1, 1908.

MR. CASPER E. YOST, president of the Nebraska Telephone Company and the Iowa Telephone Company, with headquarters at Omaha, Neb., has been made president of the Northwestern Telephone Exchange Company, succeeding H. J. Pettengill, who resigned recently to devote his time to the Southwestern Telegraph and Telephone Company, of which he is president.

MR. MILTON HARTMAN, assistant manager of the Buckeye Electric Company, Cleveland, Ohio, is the author of a very interesting article entitled "The Relation of the Home Office to the Sales Organization," in the December number of the *Selling Magazine*. Mr. Hartman analyzes the new conception of these relations and emphasizes the importance of coordination in the home and tributary organizations.

MR. WILLIAM P. CROCKETT, of Chicago, Western sales agent for a number of large electrical manufacturing companies, is just getting back to his desk after a long and severe attack of appendicitis, for which the surgeons, at this time, are unable to operate. It will be a satisfaction to Mr. Crockett's many friends, however, to know that his condition is rapidly improving and that he has every reason to anticipate a complete return to health.

ELECTRICAL SECURITIES.

The general advance in the prices of securities recorded during the first days of the month was not maintained last week, an irregular but steady sag being witnessed. This development naturally did not tend to encourage the buying public, and dealings were mainly professional. The chief cause of the decline is held to be the adverse monetary situation, which shows no sign of immediate improvement. Call money during the week went to twenty-five per cent, the highest level for some time. Further gold imports to the amount of $5,000,000 were secured, bringing the season's gold movement to $102,750,000. Of this the total gold arrivals are $79,345,000. November domestic exports, due to heavy foreign buying, reached the large total of $122,772,997, as compared with $104,943,802 for the previous year. November cotton exports are also a new high record for any month in the country's history.

Dividends have been declared upon the following electrical securities: Duluth (Minn.) Edison Electric Company; regular quarterly dividend of 1½ per cent on the preferred stock, payable January 1 to stockholders of record December 17. Toronto (Ontario) Railway Company; regular quarterly dividend of 1½ per cent, payable January 2. Union Traction Company, of Philadelphia; regular semi-annual dividend of 2½ per cent, payable January 1. Twin City Rapid Transit Company, Minneapolis, Minn.; regular quarterly dividend of 1¾ per cent on the preferred stock, payable January 2 to stockholders of record December 16. United Traction & Electric Company, Providence, R. I.; regular quarterly dividend of 1¼ per cent, payable on January 2. Cumberland Telephone and Telegraph Company; regular quarterly dividend of 1¾ per cent, payable January 1 to stockholders of record December 20. Manila Electric Railway and Light Company; a dividend of 1 per cent payable January 2 to stockholders of record December 26. Books do not close.

ELECTRICAL SECURITIES FOR THE WEEK ENDED DECEMBER 14.

New York:	*Closing.*
Allis-Chalmers common	5¾
Allis-Chalmers preferred	15½
Brooklyn Rapid Transit	37¼
Consolidated Gas	89
General Electric	112
Interborough-Metropolitan common	7
Interborough-Metropolitan preferred	17¾
Kings County Electric	80
Mackay Companies (Postal Telegraph and Cables) common	50⅜
Mackay Companies (Postal Telegraph and Cables) preferred	50
Manhattan Elevated	112
Metropolitan Street Railway	20
New York & New Jersey Telephone	96
Western Union	54½
Westinghouse Manufacturing Company	41

The guaranteed quarterly dividend of 1¾ per cent on the capital stock of the Manhattan Railway Company will be paid on and after Thursday, January 2, 1908, to stockholders of record at the closing of the transfer books on Friday, December 13, 1907. The transfer books will be reopened on December 26, 1907, at 10 o'clock A. M.

The directors of the Western Union Telegraph Company have declared a dividend of 1¼ per cent, payable in stock, on and after January 15, to stockholders of record December 20. This action is necessary largely on account of the loss in earnings incurred by the recent telegraphers' strike. The statement of earnings for the quarter ended December 31, partly estimated, shows for the three months net earnings of about $1,000,000 compared with a deficit of $311,493 the previous quarter, and with $1,616,791 in the corresponding quarter of 1906. The balance of earnings for the current quarter, after the payment of bonded interest, is placed at $566,938. Were the dividend, calling for $1,217,025, paid out of the current earnings there would be a deficit of $650,087. A deficit for the quarter is avoided, however, by the payment of the dividend in stock offset by a charge against accumulated surplus. After the payment of this dividend the company's surplus stands at $14,273,112. The stock to be used for this dividend is part of the $2,630,000 which remains in the treasury of the company out of the $14,000,000 new stock authorized in 1892. Fractions of shares will be issued in special certificates bearing no dividends, but convertible into full shares on the transfer and surrender of sufficient fractions.

Boston:	*Closing.*
American Telephone and Telegraph	100
Edison Electric Illuminating	200
Massachusetts Electric	37
New England Telephone	105
Western Telephone and Telegraph preferred	54¾

Directors of the United Gas Improvement Company have declared the regular quarterly dividend of 2 per cent, payable January 15, to stockholders of record December 31. Books do not close.

Philadelphia:	*Closing.*
Electric Company of America	8⅞
Electric Storage Battery common	31
Electric Storage Battery preferred	31
Philadelphia Electric	6¾
Philadelphia Rapid Transit	16¾
United Gas Improvement	72¼
Chicago:	*Closing.*
Chicago Telephone	105
Commonwealth-Edison	—
Metropolitan Elevated preferred	46
National Carbon common	50
National Carbon preferred	100½

DATES AHEAD.

South Dakota Independent Telephone Association. Mitchell, S. D., January 8-9, 1908.

Chicago Electrical Show. Coliseum, Chicago, January 13-25, 1908.

International Independent Telephone Association. Annual meeting, Chicago, Ill., January 21, 22 and 23, 1908.

Nebraska Independent Telephone Association. Next meeting, Omaha, Neb., January, 1908.

Wisconsin Electrical Contractors' Association. Next meeting, Milwaukee, Wis., January 15, 1908.

Ohio Independent Telephone Association. Next meeting, Columbus, Ohio, March 19, 1908.

ELECTRIC LIGHTING.

BENTON HARBOR, MICH.—Fred L. West has applied for a lighting franchise in Coloma.

LEBANON, PA.—A five-year lighting contract has been awarded to the Edison Electric Illuminating Company.

DILLON, MONT.—The Graeter Electric Company and the Dillon Electric Light and Power Company have consolidated. The former has a capital of $40,000 and the latter $100,000.

HAILEY, IDA.—The Idaho Consolidated Mines, Limited, has let the contract for a plant to generate electricity to supply power and light to its mines. Work is now under way. The plant will cost $50,000.

LONG BEACH, CAL.—Extensive improvements will be inaugurated after January 1 by the Edison Electric Company in this city. It is reported on good authority that the company plans to spend $150,000 in Long Beach on its gas and electric light service.

MINNEAPOLIS, MINN.—The Minneapolis General Electric Company has submitted to the city council a lighting proposition which reduces the present light and power rates thirty per cent, and which will result in a saving of $100,000 to the city yearly.

SCHENECTADY, N. Y.—At the annual meeting of the stockholders of the Schenectady Illuminating Company the old officers were reelected. They are: President, Hinsdill Parsons; vice-president and general manager, L. O. Ripley; secretary and treasurer, James O. Carr.

CHARLOTTE, MICH.—The Michigan Power Company, of Lansing, has applied to the council for a franchise. The company purposes extending its transmission line from Diamondale to Charlotte at a cost of $75,000, and will endeavor to interest local capital in the project.

CHAMPAIGN, ILL.—A new company has been incorporated in Clinton and has purchased the Clinton gas and electric plants. Those composing the first board of directors are: W. J. Carter, M. J. Hincheliffe, R. T. Ingham, W. W. Levering, Peter Lundin, John W. Smith and James Surdam.

MILTON, ORE.—The city council has decided to submit a proposition at the coming city election for the voting of bonds to the amount of $30,000 for the extension of the municipal electric system. The plant at present has a capacity of 160 horse-power, which will be increased to 500, if the proposition carries.

STELLA, NEB.—The Stella Electric Light Company has closed a contract for street lighting for a term of years, and will begin at once the work of installing a plant. Power will be furnished by the local meal mill. John Brenner, of Humboldt, will have charge of the work. The plant will be in operation by January 1.

IDA GROVE, IOWA—At the special election held to vote on the approval of an ordinance granting a fifteen-year franchise to the Ida Grove Electric Company to maintain a lighting and heating plant, 109 out of 118 votes were in favor of the proposition. The company contemplates many improvements and extensions to the plant next year.

VALLEJO, CAL.—E. D. Lehe, owner of electric lighting plants at Dixon, Wheatland, Rio Vista, Cordelia and towns in the Sacramento Valley, is planning to run a "farmers' line" electric system throughout the thickly populated Suisun Valley. He has obtained rights of way and sufficient contracts to guarantee the success of the system.

WALLACE, IDA.—Chicago capitalists have completed arrangements for the installation of a $140,000 electric power plant in the Clearwater district, near the mouth of Ten Mile creek. The plans provide for the development of 700 horse-power at the lowest stage of water. For several months in the year the development will reach 10,000 horse-power.

ALBANY, N. Y.—The Hudson Electric Power Company's earnings for October were $62,521. The gross earnings were $119,880, and the operating expenses were $57,359. The figures for the corresponding month last year follow: Gross earnings, $76,774; operating expenses, $52,730; net earnings, $24,044; increase, gross earnings, $43,105; operating expenses, $4,629; net earnings, $38,476.

TROY, N. Y.—At the request of the petitioner the application of the Niagara Falls Light, Heat and Power Company, to construct an electric light, heat and power plant in the city of Niagara Falls and to issue $100,000 capital stock and a mortgage for $500,000, and for permission to issue $300,000 bonds under said mortgage, has been postponed to a date not yet fixed.

DAVENPORT, IOWA—An amendment to the articles of incorporation of the Independent Light and Power Company, increasing the capital stock of the company to $1,000,000, has been filed. The amendment is signed by C. J. Von Maur as president and George M. Bechtel as secretary. The company is now erecting a gas and electric light plant in West Davenport.

SHOSHONI, WYO.—The Big Horn Power Company, of which Asmus Boysen, the Chicago capitalist, is at the head, will shortly begin work on a large dam at Boysen. Here power will be generated for electric light plants and to operate machinery in the Boysen mines along the Big Horn, street-car lines, tramways, etc. The lake created by the dam will supply storage water for irrigation.

MARTINEZ, CAL.—The Great Western Power Company, whose principal place of business is at Richmond, has filed a number of deeds of right of way. The company is engaged in the construction of an electric transmission line which in this county runs from Antioch by Concord and Walnut creek to the line between Alameda county, thence to Oakland. Its source of power is in the Sierras.

AMERICUS, GA.—The Americus Railway and Light Company, capitalized at a quarter of a million dollars, has presented its engineer's plans for the power plant to be erected, and likewise placed orders for the necessary equipment for January delivery. The work of construction begins in January and the plant, together with the electric railway system, will be completed in four months thereafter.

SALISBURY, N. C.—Work has been begun on a large powerhouse at Whitney, where the Yadkin river has been harnessed and will furnish electric power to the amount of 46,000 horse-power to the Piedmont section of North Carolina. It is expected that the power will be ready for use by March, 1908. Much of the available supply has already been contracted for by manufacturing establishments in this state.

LOCKPORT, N. Y.—The merger of the Lockport Gas and Light Company and the Economy Light, Fuel and Power Company has been finally consummated. Permission to make this merger was recently granted by the state public service commission. The new company is known as the Lockport Light, Heat and Power Company. It will begin business January 1. Oliver M. Diall will be its general manager.

SAN FRANCISCO, CAL.—The City Electric Company has closed a contract with the Westinghouse company for a 10,000-horse-power turbo-generator. This will cost $300,000. Two smaller generators of the same type are now in use by the City Electric Company. The United Railroads expects to obtain from the City Electric Company a large supply of power for running its cars, and the plant is being improved accordingly.

CHATTANOOGA, TENN.—Roswell H. Cobb, of Birmingham, president of the Coosa River Electric Power Company, has submitted to the board of army engineers, in session at Chattanooga, the plans for the company's proposed power development. These plans are identical with those of the Hydroelectric Power Company. It is desired to develop power at the Ten Island Shoals, on the Coosa river, situated fourteen miles from Anniston and forty-eight from Birmingham.

GLASTONBURY, CT.—The Glastonbury Power Company has awarded to F. T. Ley & Company, of Springfield, the contract for the construction of a power plant on Roaring Brook in Cotton Hollow in South Glastonbury. An expenditure of about $200,000 is involved in the contract. Work will begin early in the spring and it is expected that the plant, which will be capable of generating 1,300 horse-power, will be ready for use in the fall. Electricity will be furnished for power and lighting in Glastonbury, Manchester and Rocky Hill.

RITZVILLE, WASH.—It is understood that the Washington Water Power Company, of Spokane, is surveying for a power line

that will when completed furnish light and power to a great portion of the Inland Empire. From Spokane the line will run to Medical Lake, on the Central Washington Railroad; thence to Davenport, the county seat of Lincoln county; to Harrington on the Great Northern Railroad; to Ritzville and then west to Lind and perhaps farther west to Pasco. It is understood that the line will be complete to this point by June 1.

EASTON, PA.—Application will be made on December 30 next to the state authorities for a charter for the Clymer Power Company by Lee S. Clymer and B. F. Fackenthal, Jr., of Riegelsville, and John S. Fackenthal, M. A. Maxwell and Elbridge Walker, of Easton. The object of the corporation is the manufacture and supply of gas or the supply of light, heat and power by means of electricity, or the supply of light, heat or power to the public by any other means. The plant is located on the site of the old Lehigh company, along the canal, about one mile below Raubsville.

SACRAMENTO, CAL.—The report of Professor C. L. Cory, of the California State University, to the city council on the cost of establishing a municipal electric light plant, has been submitted. The report states that the estimated cost of establishing a light and power plant, including forty-two miles of pole line and the installation of 600 arc lamps, and 184 electroliers in the business section, would total approximately $273,200. The cost of each lamp per month (moonlight schedule included), would be $5.75, or a saving of $1.25 on each over the present cost. There are 506 arc lamps in the city at the present time costing $7 each per month.

AMHERST, MASS.—The Connecticut River Power Company has completed its cable line connecting the Amherst Gas Company with its plant in Turners Falls. The line is twenty miles in length and the system includes three separate wires. The generators installed at Turners Falls have a capacity at present of 3,000 horsepower. The water power is sufficient to operate additional generators when they shall be required. The steam plant of the Amherst Gas Company will be kept in reserve for use in emergencies. Electricity will be furnished for lighting Amherst, Pelham, Hatfield, Sunderland and South Deerfield. Power is also furnished to several manufacturers.

GARDNER, MASS.—The state board of gas and electric light commissioners has granted the petition of the Gardner Electric Light Company, that it be allowed to issue additional stock and bonds. Under the order sent out the company is to be allowed to issue 350 shares at par of $100, and $65,000 of bonds. The proceeds of said stock and bonds are to be applied to the following purposes: Twenty thousand dollars to the payment and cancellation of the mortgage note for that amount, $40,000 to the payment and cancellation of an equal amount of the indebtedness of the company represented by its other promissory notes outstanding on June 30, 1907, and $40,000 to the payment of the cost of additions to plant made subsequent to said thirtieth day of June.

ESCANABA, MICH.—The Escanaba common council has accepted the contract proposed by the Escanaba Electric Pulp and Power Company to furnish power for the operation of the municipal lighting plant for a period of ten years. By the terms of the contract the company has agreed to complete the plant now under process of construction at the old Flat Rock mill site on the Escanaba river by July 1 of next year and to furnish power from that date to the city until July 1, 1918. By additions that were made to the contract before it was formally adopted four new provisions were added. They provide as follows: The city shall have the right to sell the municipal plant at any time within the ten-year period covered by the company's lease of the machinery, provided that the purchaser shall assume all of the risks and duties which the city now holds under its lease. The power company agrees to bear all expense over $4,000 entailed in installing necessary machinery to allow the new power to be received at the municipal plant. The company agrees to furnish current of proper quality to allow the use of the present arc light system in Escanaba until such a time as the city will be able to purchase equipment permitting the use of the company's proposed alternating-current system. At any time within the tenth year of the life of the contract the city shall have the right to enter the municipal plant to install new machinery which will allow the city to furnish its own lights after the expiration of the present contract.

ELECTRIC RAILWAYS.

BELLEVILLE, ILL.—A notice of increase of capital stock has been filed by the Southern Traction Company of Illinois. The increase is from $2,500 to $1,500,000.

COLUMBUS, OHIO—Notice has been filed with the secretary of state by the Massillon, Wooster & Mansfield Traction Company of an increase of capital stock from $1,000 to $1,000,000.

PITTSFIELD, MASS.—The aldermen have extended until December 15, 1908, the West Pittsfield franchise of the Pittsfield Street Railway Company, which expired December 15.

CINCINNATI, OHIO—The Cincinnati Traction Company has secured permission from the government to construct two intake piers and two tunnels on the Ohio river. The work will cost about $50,000.

NORTH ADAMS, MASS.—President Storrs of the Berkshire Street Railway Company has asked legislative authority to purchase the franchise and property of the Bennington & North Adams Street Railway Company.

NIAGARA FALLS, ONTARIO—The Chippewa village council has granted an additional franchise to the International Railway Company to operate cars in certain streets, in return for which the company will furnish electric current to maintain ten arc lights in the village streets.

MUSKOGEE, OKLA.—The Ardmore Light and Power Company has sold its power and ice plant, together with its street-car franchise, to Donald Fitzgerald, of New York, for $25,000. The new company is to complete three miles of street-railway track and have it operating by the first of next July.

CLEVELAND, OHIO—Owen H. Wilcox has been appointed receiver of the Cleveland & Sharon Electric Railroad Company. The petition was filed by the company's president, Francis B. Morgan. The traction company was organized under the laws of Ohio, with a capital stock of $2,500,000 and has issued $2,500,000 in bonds.

HARTFORD, CT.—One of the interesting features of the annual report of State Tax Commissioner Corbin, of Connecticut, is a statement of the trolley express business. This amounted to $43,434.20, while the receipts of the Adams Express Company were less than eight times as much. The business is still in its infancy.

BALTIMORE, MD.—The Noel Construction Company has been awarded the contract by the United Railways Company for the erection of a five-story building inside the Pratt street power-house. This new structure will be of reinforced concrete and brick material and will be absolutely fireproof. It will have a width of twenty-eight feet and a depth of eighty-four feet.

BELLEVILLE, ILL.—Articles of incorporation of the Red Bud & Belleville Interurban Railroad Company have been filed. The incorporators are: Conrad Becker, Herman Schrieber and Dr. C. G. Smith, of Red Bud; John Keller, of Hecker, Ill., and Ben A. Gundlach, of Belleville, Ill. The road is to be built from Red Bud to Smithton and Belleville. There are twenty-five subscribers to the stock in Red Bud.

PITTSBURG, PA.—The Westinghouse Electric and Manufacturing Company has taken a contract for the apparatus for the Penn & Franklin Street Railway Company, which will build a road between Pittsburg and the Westinghouse works at East Pittsburg, a short route in competition with the two lines of the Eastern Pittsburg Railways Company of the Philadelphia company which now run there. The contract is worth $150,000.

ST. PAUL, MINN.—By a lease signed recently the Twin City lines will electrify and operate that portion of the Minneapolis & St. Louis line between Manitou and Tonka Bay, Lake Minnetonka. The trolley company will build a mile and a half of line from its present terminus at Excelsior to Manitou, and will improve the mile and a half of the Minneapolis & St. Louis track from that point to Tonka Bay.

HARRISBURG, PA.—A line from this city to Washington, D. C., by trolley, by way of Carlisle, Gettysburg and Frederick, Md., is projected. It is proposed to extend the Washington, Frederick & Gettysburg Railway from Frederick to Great Falls; there it is to connect with the Old Dominion line and run into the national capital. Sufficient money for the preliminary survey has been sub-

scribed, and this has been started. It will be a direct line, and will cost approximately $1,000,000.

SYRACUSE, N. Y.—Directors of the Syracuse Rapid Transit Railway Company and the East Side Traction Company were elected for the ensuing year at a meeting held in the Rapid Transit office as follows: Horace E. Andrews, Cleveland, Ohio; H. D. Coffinberry, Cleveland, Ohio; John Carstensen, New York city; T. H. Conderman, Philadelphia, Pa.; W. P. Gannon, Syracuse, N. Y.; H. R. Newcomb, Cleveland, Ohio; E. V. W. Rossiter, New York city; John J. Stanley, Cleveland, Ohio; W. K. Vanderbilt, Jr., New York city.

ROCKVILLE, CT.—The plans in connection with the fast interurban electric service between Rockville and Hartford, and also between Rockville and Melrose, call for the discontinuance of all the steam trains operating on the Rockville and Melrose branches of the New Haven system. The New York, New Haven & Hartford Railroad Company will turn the operation of the new service over to the Connecticut company. It is intended to haul all freight in and out of Rockville over the Melrose branch and to employ electric power, and it will not be necessary for any steam trains to enter the city. This is the first experiment which the New Haven road has made in the employment of electricity on an extensive scale for the hauling of freight.

PHILADELPHIA, PA.—The stockholders of the Easton Consolidated Electric Company have approved the plan arranged some time ago for the consolidation of the underlying properties owned and controlled by it. The Easton Consolidated is a holding company owning all of the stock of the Easton Transit Company, which owns and controls the Easton, Palmer & Bethlehem Street Railway Company, the Easton & Bethlehem Transit Company and the Northampton Central Street Railway Company. The Consolidated stockholders also ratified the issue of dividend obligations of the Easton Transit Company to the amount of $180,000, and of the Edison Illuminating Company to the amount of $67,743, issued to and owned by the Consolidated, and representing advances made for improvements.

GREENVILLE, S. C.—The Greenville Interurban Company has begun a survey of its proposed line from Williamston to Greenville, and is now engaged in securing rights of way from another line, which it proposes to build from Greenville to Spartanburg. At a recent meeting of the stockholders, several new directors were added to the board, and changes were made in the officers. H. H. Prince resigned as president, and John C. Carey, until recently the head of the Lockhart Cotton Mills, was elected to succeed Mr. Prince. Mr. Carey will shortly come to Greenville to live. A. A. Gates, was elected vice-president, and C. C. Good secretary and treasurer. H. H. Prince was elected general manager. A. L. Scott, of the engineering firm of Lockwood, Green & Co., of Boston, was added to the board of directors, with Dr. George E. Coughlin, who promoted the Anderson Traction Company. It is announced that the company has completed all necessary arrangements for financing the enterprise.

WORCESTER, MASS.—A. George Bullock, vice-president of the Worcester Consolidated Street Railway Company, and Treasurer Justin W. Lester were not reelected at a directors' meeting. L. S. Storrs, vice-president of the New England Investment and Security Company, the holding company of the Worcester Consolidated street railway and other street railways in Massachusetts controlled by the New York, New Haven & Hartford Railroad, was elected vice-president; L. S. Candee, Boston, treasurer of the New England Investment and Security Company, and treasurer of the roads under its control, with consolidated offices in Boston, was elected treasurer. J. T. Harmer, Boston, was elected comptroller and clerk, positions held by Mr. Lester. At a stockholders' meeting these directors were elected: A. G. Bullock, Francis H. Dewey, L. N. Kinnicutt, Worcester; A. D. Foster, J. A. Parker, Boston; F. W. Kendrick, New York; Charles E. Ware, Fitchburg; L. S. Storrs, Brookline, and B. W. Warren, Williamstown and Boston. The directors elected these officers: President, F. H. Dewey; vice-president, L. S. Storrs, comptroller and clerk, J. T. Harmer, Boston; treasurer, L. S. Candee.

BOSTON, MASS.—At the annual meeting of the West End Street Railway Company the following directors were elected for the ensuing year: Edwin F. Atkins, Charles M. Baker, Parkman Dexter, John Parkinson, Joseph B. Russell, C. Minot Weld, Stephen M. Weld, Charles A. Williams, Moses Williams and Alfred Winsor. During the year $500,000 par value of the four-per-cent bonds of the company, due August 1, 1932, was sold and the proceeds used to pay for a like amount of the bonds of the Boston Consolidated Railway Company, due January 1, 1907. The premium received from the sale of these bonds was $2,290. The bonded debt of the company has been reduced $8,000 by the payment of $2,000 par value bonds of the West End Street Railway Company due November 1, 1902, and $6,000 par value of the bonds of the Charles River Street Railway Company due April 1, 1904. The common stock of the company was increased during the past year by the issue of 8,400 shares, 7,270 of which were taken by the stockholders of the company and 1,130 sold at auction. The premium above par received from the sale of this stock was $286,432.90. The proceeds from the sale of this stock were used to pay to the Boston Elevated Railway Company the audited accounts for additions and improvements made to the property of this company during the two years ended March 30, 1906. Two other accounts, covering the year to March 30, 1907, have been received from the Boston Elevated Railway Company, but have not yet been audited and approved. The dividends on the capital stock of the company for the past year, amounting to $1,204,947.50, and interest on the funded debt and taxes, have been paid by the Boston Elevated Railway Company.

NEW MANUFACTURING COMPANIES.

PORTLAND, ORE.—Articles of incorporation have been filed for the Portland Electric Sign Works, with a capital stock of $3,000. The incorporators are: C. A. Stenman, M. D. Bromberger and L. Ainsworth Smith.

CHICAGO, ILL.—The Bankers' Alarm Protection Company has been incorporated with a capital stock of $3,000 to manufacture and deal in electrical appliances. The incorporators are: J. O. Jacobsen, George English and Enos Weiant.

SALT LAKE CITY, UTAH—The Electric Utility Company, of Salt Lake, has filed articles of incorporation. The capital stock is $25,000, with shares at $2.50 each. The company will buy, sell and manufacture all kinds of electrical appliances. The officers are: E. J. Raddatz, president and treasurer; John Bestelmeyer, vice-president; H. G. Snyder, secretary.

INDUSTRIAL ITEMS.

THE PITTSBURG TRANSFORMER COMPANY, Pittsburg, Pa., is distributing a folder containing letters commendatory of the Pittsburg thawer for thawing frozen pipes.

THE H. W. JOHNS-MANVILLE COMPANY, 100 William street, New York city, has published two new folders, devoted, respectively, to the "Electrotherm" and to "Asbestocel" covering for residence furnaces.

FRANK MOSSBERG COMPANY, Attleboro, Mass., in catalogue No. 10, describes and illustrates a fine line of wrenches, bells, sheet-metal stampings, punching and forming dies, special tools and machinery.

THE H. T. PAISTE COMPANY, Philadelphia, in bulletin No. 49, dated December, 1907, describes and illustrates the Paiste cross-over insulator, plain molding cross-overs, various types of iron boxes and improved designs of panelettes.

THE GERMANIA ELECTRIC LAMP COMPANY, 420 Ogden street, Newark, N. J., reports that it has lately installed additional automatic lamp-making machinery of the latest type and is now in better shape than ever before to fill orders promptly.

THE ELDREDGE ELECTRIC MANUFACTURING COMPANY, Springfield, Mass., has ready for distribution a catalogue illustrating and describing battery-testing instruments. These include the "Eclipse" battery ammeter, the Eldredge battery voltmeter, and the "Advance" voltmeter, pocket volt-ammeter and miniature switchboard meters.

THE NEWTON MACHINE TOOL WORKS, INCORPORATED, Philadelphia, Pa., has issued a handsome new catalogue, No. 45, superseding all previous issues. This is substantially bound in

green boards and copiously illustrated. Brief descriptions of the company's general lines are given, which will be supplemented by detailed information upon application.

THE WISCONSIN ENGINE COMPANY, Corliss, Wis., manufacturer of heavy-duty Corliss engines, announces that it has been awarded a contract by the city of Atlanta, Ga., for a 20,000,000-gallon vertical, triple-expansion, crank and flywheel pumping engine, to have a guaranteed duty of not less than 170,000,000-foot pounds per 1,000 pounds of dry steam.

THE ALLIS-CHALMERS COMPANY, Milwaukee, Wis., will be pleased to send bulletin No. 1,501, devoted to belted Reliance Corliss engines, to any one interested, upon request. The sales of this engine have not decreased since the more general introduction of other prime movers such as gas engines and steam and hydraulic turbines. The popularity which these engines have attained must be due to their reliability, durability and simplicity of construction.

THE GENERAL ELECTRIC COMPANY, Schenectady, N. Y., has issued a bulletin, No. 4554, describing the Type P-3, portable voltmeters, ammeters and wattmeters. The advantages claimed for these instruments are: Strength, lightness and small size, so that several instruments may be carried with ease; a light-weight moving element not susceptible to damage in transportation, and their ability to give accurate indications when used in the vicinity of external magnetic fields. Catalogue numbers, capacities and list prices are given in the bulletin, and full-size sample scales of the various instruments reproduced. The company has also issued a little booklet giving sample plans of the wiring of several rooms to illustrate the use of the standard symbols for wiring which have been adopted by the National Electric Contractors' Association and the American Institute of Architects. The booklet shows as well some of the General Electric Company's specialties which might be used in carrying out the plans shown in the diagrams.

THE ADAMS-BAGNALL ELECTRIC COMPANY, Cleveland, Ohio, is distributing a series of bulletins, including bulletin No. 3, on directions for operating the company's constant direct-current series-enclosed arc lamps; No. 5, descriptive of the A-B direct-current, constant-potential series-enclosed arc lamp; No. 7, directions for operating 220-volt, constant-potential, alternating enclosed arc lamps; No. 6, directions for installing Adams-Bagnall alternating constant-current regulators; No. 8, directions for operating A-B constant-potential, alternating enclosed arc lights; No. 9, directions for operating A-B 220-volt, direct-current, constant-potential lamps; No. 10, directions for operating A-B constant-potential, alternating enclosed arc lamps; No. 15, descriptive of the company's constant direct-current series-enclosed arc lamp, and No. 19, dealing with alternating-current, series arc lighting; No. 30, descriptive of the A-B direct-current, constant-potential, enclosed arc lamp for 100-130-volt circuits; No. 31, dealing with the same type of lamp for 220-250-volt circuits, and No. 32, with lamps for operation, two in series, on 210 to 250 volts. Bulletin No. 33 describes the A-B electric arc lamp for blue-printing, photo-engraving and similar work; bulletin No. 55, the A-B alternating-current, constant-potential, enclosed arc lamp for 100 to 130-volt circuits, and No. 56, the same type of lamp, for 210-250-volt circuits. The Adams-Bagnall Company will be pleased to send any of this literature upon request.

Record of Electrical Patents.

Week of December 10.

873,005. KNIFE-SWITCH. Henry P. Ball, New York, N. Y., assignor to General Electric Company. The contact piece has a tongue between the slots.

873,006. RHEOSTAT. Henry P. Ball, New York, N. Y., assignor to General Electric Company. A rheostat with overload and underload disengaging devices.

873,017. TROLLEY-WIRE EAR. William G. Carey, Schenectady, N. Y., assignor to General Electric Company. A clamping trolley ear.

873,036. TRANSFORMER. John J. Frank, Schenectady, N. Y., assignor to General Electric Company. The coils are arranged for series connections between two sets of secondary coils.

873,053. ELECTRIC CONDENSER. Frank S. Koch, Chicago, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill. A condenser formed of a folded roll of alternate conducting and non-conducting materials.

873,061. ELECTRICAL CONTROL APPARATUS FOR STEAM GENERATORS. Ralph Lomax and John Tomlinson, Darwen, England. The strength of the current in the main electrical circuit is controlled by the rise and fall of the pressure in the steam generator.

873,064. SYSTEM OF MOTOR CONTROL. Wilbur L. Merrill, Schenectady, N. Y., assignor to General Electric Company. The speed of the drive is controlled through two or more motors.

873,072. DYNAMOELECTRIC MACHINE. Jakob E. Noeggerath, Schenectady, N. Y., assignor to General Electric Company. A homopolar generator.

873,078. ELECTROMAGNET FOR TELEGRAPHONE PURPOSES. Peder O. Pedersen and Valdemar Poulsen, Copenhagen, Denmark, assignors to American Telegraphone Company. Electromagnets with their opposite poles arranged obliquely.

873,083. TELEGRAPHONE. Valdemar Poulsen and Peder O. Pedersen, Copenhagen, Denmark, assignors to American Telegraphone Company. An apparatus for recording speech on a magnetic body.

873,084. TELEGRAPHONE. Valdemar Poulsen, Copenhagen, Denmark, assignor to American Telegraphone Company. The record is made on a sheet of metal.

873,098. METER. Ernest Schattner, Schenectady, N. Y., assignor to General Electric Company. An electrolytic meter for alternating-current circuits.

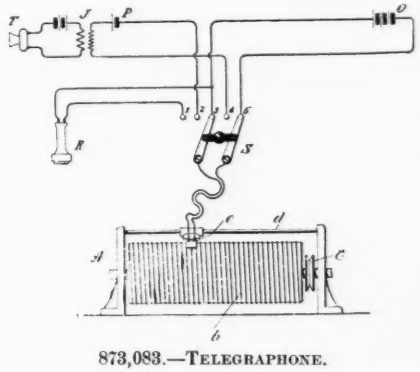
873,101. REGENERATIVE SYSTEM FOR BRAKING. Walter I. Slichter, Schenectady, N. Y., assignor to General Electric Company. One of a group of motors is used as the exciter for the others.

873,104. LAMP RECEPTACLE. James S. Stewart, New York, N. Y., assignor to Annie Stewart, New York, N. Y. A receptacle for molding.

873,107. SYSTEM OF DISTRIBUTION. John B. Taylor, Schenectady, N. Y., assignor to General Electric Company. A distribution system for alternating-current electric railways.

873,108. ELECTRIC-LAMP HOLDER. Charles E. Throop and Samuel A. Freeman, Buffalo, N. Y., assignors to Olin Gas Engine Company, Buffalo, N. Y. An adjustable holder.

873,132. ELECTRIC ACCUMULATOR. Quintin Marino and Edward W. Barton-Wright, London, England. A battery with horizontal plates.



873,083.—TELEGRAPHONE.

873,139. APPARATUS FOR USE IN STARTING AND CONTROLLING ELECTRIC MOTORS. Abraham Taylor, Rishton, and Thomas Eaton and Herman Schwartz, Manchester, England. A liquid motor-starter.

873,166. TRANSFORMER. Louis C. Nichols, Norwood, Ohio, assignor to the Bullock Electric Manufacturing Company. An air-cooled transformer.

873,171. MOTOR-CONTROL SYSTEM. Walter J. Richards, Norwood, Ohio, assignor to Allis-Chalmers Company. A motor and generator are combined with opposed field windings and means for short-circuiting one or the other.

873,177. SYSTEM OF MOTOR CONTROL. William F. Schneider, Norwood, Ohio, assignor to Allis-Chalmers Company, and the Bullock Electric Manufacturing Company. A combined reversing and series-parallel controller.

873,215. JOINT FOR METAL-SHEATHED CABLES. Charles W. Davis, Edgeworth, Pa., assignor to Standard Underground Cable Company, Pittsburg, Pa. An insulated lead coupling for metal-sheathed cables.

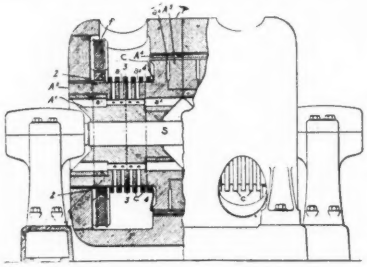
873,216. ELECTRIC CABLE. Charles W. Davis, Edgeworth, Pa., assignor to Standard Underground Cable Company, Pittsburg, Pa. A stranded cable with insulation which will give way at a certain critical temperature.

873,220. REVERSIBLE GALVANIC BATTERY. Thomas A. Edison, Llewellyn Park, Orange, N. J., assignor to Edison Storage Battery Company, Orange, N. J. A depolarizable electrode of nickel and bismuth hydroxides.

873,263. ELECTRIC-CIRCUIT CONTROLLER. William A. Paris, Edgewood Park, Pa., assignor to Westinghouse Electric and Manufacturing Company. A controller automatically returned to the off position by a pair of electromagnets.

873,264. CONTROLLER FOR ELECTRIC MOTORS. William A. Paris, Edgewood Park, Pa., assignor to Westinghouse Electric and Manufacturing Company. A controller which carries the motor through a predetermined operation.

873,284. CONTROL SYSTEM FOR ELECTRIC MOTORS. Louis M. Aspinwall, Wilkinsburg, Pa., assignor to Westinghouse Electric and Manufacturing Company. A controller with a master switch operating a plurality of motor switches.



873,072.—DYNAMO-ELECTRIC MACHINE.

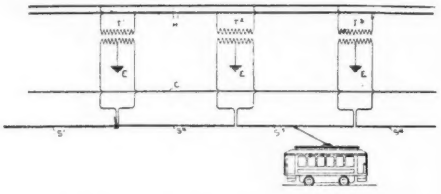
873,290. ELECTRIC APPARATUS. Howard L. Beach, Wilkinsburg, Pa., assignor to Westinghouse Electric and Manufacturing Company. A pair of electromagnets producing a reciprocating motion.

873,298. ELECTRIC-MOTOR CONTROL. William Cooper, Wilkinsburg, Pa., assignor to Westinghouse Electric and Manufacturing Company. An electromagnetically adjustable automatic limiting device controlling the operation of motor switches.

873,312. ELECTRICALLY OPERATED COAL-HOIST. Clark T. Henderson, Pittsburg, Pa., and Norman C. Bassett, Milwaukee, Wis., assignors to the Cutler-Hammer Manufacturing Company, Milwaukee, Wis. An automatic starter for an elevator motor.

873,317. ELECTRIC HEATER. Moise Landrey, Merced, Cal. A heating element laid between wood veneer boards.

873,328. PROCESS OF PRODUCING SILICIDS. Edgar F. Price, Niagara Falls, N. Y., assignor, by mesne assignments, to Central Trust Company of New York. A charge containing a silicon compound, an alloying metal and carbon is treated in an electric furnace.



873,107.—SYSTEM OF DISTRIBUTION.

873,351. SYSTEM OF CONTROL. Frederick Darlington and Otto S. Schairer, Pittsburg, Pa., assignors to Westinghouse Electric and Manufacturing Company. A device for connecting a motor across either side of a three-wire system.

873,356. PREPAYMENT ATTACHMENT FOR ELECTRICITY METERS. Francis J. Dowling, Montreal, Quebec, Canada. A prepayment device for attaching to electric meters.

873,362. LOCK-OUT SWITCH FOR PARTY TELEPHONE LINES. Oscar F. Forsberg, Chicago, Ill., assignor to Western Electric Company. A lock-out device operated by a magnet and ratchet.

873,375. GROUND PLATE. Budd J. Jones, Cincinnati, Ohio. A composite ground plate.

873,382. STORAGE-BATTERY GRID. Joseph Marx, Buffalo, N. Y. A grid provided with a series of superposed horizontal extending bars.

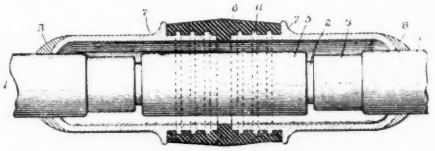
873,414. ARC LAMP. Walter E. Daniels, Chicago, Ill. An arc lamp with divided globe for fitting on a pole top.

873,415. ARC LAMP. Walter E. Daniels, Chicago, Ill. An arc lamp with undivided globe for fitting on a pole top.

873,419. TROLLEY AND HARP THEREFOR. Samuel F. Estell, Los Angeles, Cal., and Frederick W. G. Phillips, Wilmette, Ill. A flexible wheel mounting.

873,444. TROLLEY WHEEL. Ellsworth N. Luburg, Baltimore, Md., assignor of one-third to William Wesley Varney and one-third to Albert Henry Smith, Baltimore, Md. Special provision is made for securing lubrication.

873,456. WIRE-CARRYING CROSS-ARM AND INSULATOR THEREFOR. Edwin C. Ottinger, Newport, Pa.; Walter Scott Ottinger, Sr., administrator of said Edwin C. Ottinger, deceased, assignor of one-third to Jennie E. Ottinger, and one-third to Walter S. Ottinger, Sr., Philadelphia, Pa., and one-third to Samuel H. Bair, Newport, Pa. A compound cross-arm.



873,215.—JOINT FOR METAL-SHEATHED CABLES.

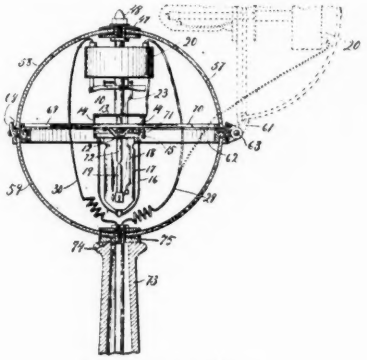
873,468. AUTOMATIC BLOCK-SIGNALING SYSTEM FOR ELECTRIC RAILWAYS. Fitzhugh Townsend, New York, N. Y.; John J. Townsend, administrator of said Fitzhugh Townsend, deceased, assignor to General Railway Signal Company. A direct-current signaling system for alternating-current railways.

873,492. INSULATED RAIL JOINT. James H. Brothers, Newark, N. J., assignor to the Rail Joint Company. Discontinuous filler members are placed between the rails and the splice bars.

873,508. ELECTRODEPOSITION OF COPPER AND OTHER METALS. Sherard O. Cowper-Coles, London, England. The electrolyte is purified by atomizing.

873,512. FACE-HARDENED STEEL PLATE. Cleland Davis, U. S. Navy, assignor, by mesne assignments, to Carnegie Steel Company, Pittsburg, Pa. The surface of the plate is heated electrically.

873,541. METHOD OF RECEIVING AND STRENGTHENING THE REPRODUCTION OF SPEECH, SIGNALS, ETC. Emil S. Hagemann, Copenhagen, Denmark. A device for recording a plurality of records and combining them for reproduction.



873,414.—ARC LAMP.

873,588. PARTY-LINE TELEPHONE SYSTEM. Norman S. Page, New York, N. Y. A party-line system with lock-out devices.

873,605. TRAIN-CONTROLLING MEANS. Ernest Renaud, Montreal, Quebec, Canada, assignor to J. B. Dupuis, Montreal, Canada. An electromagnetically controlled system for stopping locomotives.

873,640. RIVETING APPARATUS. Benjamin Waddington, New Castle, Pa., assignor to Lee M. Raney, New Castle, Pa. The work to be riveted is held by electromagnets.

873,660. BATTERY CONNECTION. George P. Blow, La Salle, Ill. A sheet-metal connector for battery carbons.

873,674. ELECTRICAL TESTING SYSTEM. Howard E. Miller, St. Louis, Mo. A system for locating grounds.

873,700. ROTATING BRACKET FOR THE SUSPENSION OF ELECTRIC WIRES. Charles E. Buckbee, Flushing, Mich. An oscillating insulator support.